CBCT ANALYSIS OF PATIENTS WITH MALIGNANCY INVOLVING MANDIBLE- A CROSS-SECTIONAL DESCRIPTIVE STUDY

A Dissertation Submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

For partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

BRANCH – IX

ORAL MEDICINE AND RADIOLOGY

THE TAMIL NADU DR. MGR MEDICAL UNIVERSITY
CHENNAI – 600 032

2015 – 2018

CERTIFICATE BY THE GUIDE

This is to certify that **Dr. BHAUMIK JOSHI**, Post graduate student (2015 – 2018) in the Department of Oral Medicine and Radiology (Branch IX), Tamil Nadu Government Dental College and Hospital, Chennai – 600 003 has done this dissertation titled **"CBCT ANALYSIS OF PATIENTS WITH MALIGNANCY INVOLVING MANDIBLE- A CROSS-SECTIONAL DESCRIPTIVE STUDY"** under my direct guidance and supervision for partial fulfillment of the M.D.S degree examination in 2018 as per the regulations laid down by Tamil Nadu Dr.M.G.R. Medical University, Chennai -600 032 for **M.D.S., Oral Medicine and Radiology (Branch – IX)** degree examination.

Dr. S. JAYACHANDRAN, M.D.S., Ph.D, MAMS. MBA

Professor and Head of the Department

Department of Oral Medicine and Radiology

Tamil Nadu Government Dental College & Hospital

Chennai – 600 003

CERTIFICATE BY HEAD OF THE DEPARTMENT/ HEAD OF THE INSTITUTION

This is to certify that the Dissertation titled **"CBCT ANALYSIS OF PATIENTS WITH MALIGNANCY INVOLVING MANDIBLE - A CROSS-SECTIONAL DESCRIPTIVE STUDY"** is a bonafide work done by **Dr. BHAUMIK JOSHI,** Post graduate student (2015 – 2018) in the Department of Oral Medicine and Radiology under the guidance of **PROF. DR S. JAYACHANDRAN, MDS, PhD,** Professor and Head, Department of Oral Medicine and Radiology, Tamil Nadu Govt Dental College and Hospital – 600 003.

THE PRINCIPAL

Tamil Nadu Govt Dental College & Hospital,

Chennai – 600 003.

Dr. S. JAYACHANDRAN

MDS., PhD, MAMS. MBA

Professor and Head of the Department

Department of Oral Medicine and Radiology

Tamil Nadu Government Dental College & Hospital

Chennai – 600 003

DECLARATION

Title of dissertation	**CBCT Analysis of patients with malignancy involving mandible-A Cross-sectional Descriptive Study**
Place of study	**Tamil Nadu Government Dental College and Hospital, Chennai-600003**
Duration of the course	**3 Years**
Name of the guide	**DR. S. JAYACHANDRAN, MDS, Ph.D., MAMS, MBA.**
Head of the department	**DR. S. JAYACHANDRAN, MDS, Ph.D., MAMS, MBA.**

I **Dr BHAUMIK JOSHI** hereby declare that no part of the dissertation will be utilized for gaining financial assistance/any promotion without obtaining prior permission of the Principal, Tamil Nadu Government Dental College and Hospital, Chennai-600003. In addition, I declare that no part of this work will be published either in print or in electronic media without the guide who has been actively involved in the dissertation. The author has reserves the right to publish the work with the prior permission of the Principal and Guide, Tamil Nadu Government Dental College & Hospital, Chennai-600003.

Guide and Head of the Department **Signature of the candidate**

URKUND

Urkund Analysis Result

Analysed Document:	DR BHAUMIK JOSHI THESIS.docx (D34514247)
Submitted:	1/10/2018 4:54:00 AM
Submitted By:	drbjoshi11@gmail.com
Significance:	0 %

Sources included in the report:

Instances where selected sources appear:

0

CERTIFICATE – II

This is to certify that this dissertation work titled "CBCT ANALYSIS OF PATIENTS WITH MALIGNANCY INVOLVING MANDIBLE - A CROSS-SECTIONAL DESCRIPTIVE STUDY of the candidate DR. BHAUMIK JOSHI with registration Number 241527002 for the award of MASTER OF DENTAL SURGERY in the branch of ORAL MEDICINE AND RADIOLOGY (BRANCH - IX).

I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows 0% percentage of plagiarism in the dissertation.

Guide & Supervisor sign with Seal.

ACKNOWLEDGEMENT

I extend my special thanks to our **Principal Dr. B. SARAVANAN, MDS , Ph.D,** Tamil Nadu Government Dental College And Hospital, Chennai- 600 003 for providing motivation and encouraging environment to conduct this study

With supreme sincerity, deep sense of gratitude and heartfelt appreciation I thank my esteemed guide **Dr. S.JAYACHANDRAN, M.D.S., Ph.D, MAMS**., Professor and Head, Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai – 3, for his valuable guidance, support and encouragement throughout my post graduate course and to bring this dissertation to a successful completion. He has always been very significant and analytical from a wholly constructive viewpoint, always making suggestions to improve not only this study, but also my entire approach to the subject and its practice.

It is my privilege to extend my sincere gratitude and heartfelt thanks to esteemed **Dr. G. V. MURALI GOPIKA MANOHARAN, M.D.S.,** Professor, Department of Oral Medicine and Radiology, for his valuable guidance and sincere support throughout my post graduation.

My sincere and humble regards and gratitude to **Dr. L. KAYAL MDS,** Professor**, Dr. CAPT. P. REGU MDS, Dr. K. SARALA, MDS, Dr. VIDYA JAYARAM**, **MDS, Dr. AARTHI NISHA, MDS**, Assistant Professors, Department of Oral Medicine and Radiology for their help and suggestions during my course

I dedicate this work to my ever supporting parents **Mrs. SONABEN C. JOSHI and Mr. CHANDRAKANT B. JOSHI,** my brother **Dr. UMANG C. JOSHI** and all my family

members for their encouragement, support, love, kindness and prayers without whom I wouldn't have achieved anything in my life.

A very special note of thanks to my fiancée **Dr. RIYA DAVE JOSHI** for her prayers, guidance, patience, love and support throughout my course.

I would like to thank my co- post graduate **Dr D. PRASANNA** for his support and help throughout the duration of my post graduation. I would also like to thank all my seniors and juniors for all their help. I am very grateful, and extend my sincere thanks to Radiographers of Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai – 3.

I am very grateful, and extend my sincere thanks to Department of Oral and Maxillofacial Pathology, Tamil Nadu Government Dental College and Hospital, Chennai – 3 for providing histopathological analysis in his the study.

I thank all my patients who were kind enough and cooperative to participate in my study. I also thank my post graduate colleagues for their help and constant support.

Lastly, I wholeheartedly thank the ALMIGHTY who has showered blessings from above and who is behind each and every step in my life

CONTENTS

LIST OF ABBREVATIONS

AJCC	**AMERICAN JOINT COMMITTEE ON CANCER**
ET AL	**AND OTHERS**
CBCT	**CONE BEAM COMPUTED TOMOGRAPHY**
DSA	**DIGITALLY SUBTRACTED ANGIOGRAPHY**
FOV	**FIELD OF VIEW‘S**
FPD	**FLAT PANEL DETECTORS**
GD-DTPA	**GADOLINIUM-DIETHYLENETRIAMINEPENTAACETATE**
IAN	**INFERIOR ALVEOLAR NERVE**
KV	**KILO VOLTAGE**
MRI	**MAGNETIC RESONANCE IMAGING**
µSV	**MICROSIEVERTS**
MA	**MILLIAMPERE**
MSV	**MILLISIEVERTS**

MDCT	**MULTIDIMENSIONAL COMPUTED TOMOGRAPHY**
NRCP	**NATIONAL COUNCIL ON RADIATION PROTECTION**
N	**NUMBER**
OSCC	**ORAL SQUAMOUS CELL CARCINOMA**
PET	**POSITRON EMISSION TOMOGRAPHY**
ROC	**RECEIVER OPERATING CHARACTERISTIC**
SPECT	**SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY**
SPSS	**STATISTICAL PACKAGE FOR SOCIAL SCIENCES**
TNM	**TUMOR-NODE-METASTASIS**
UICC	**UNION FOR INTERNATIONAL CANCER CONTROL**
WHO	**WORLD HEALTH ORGANISATION**
2-D	**2-DIMENSIONAL**
3-D	**3- DIMENSIONAL**

LIST OF PHOTOGRAPHS

FIGURE 8A	**BUCCAL CORTEX PERFORATION**
FIGURE 8B	**LINGUAL CORTEX PERFORATION**
FIGURE 8C	**BICORTICAL PERIOSTEAL REACTION**
FIGURE 9	**PATHOLOGICAL FRACTURE OF LEFT BODY OF MANDIBLE**
FIGURE 10A	**WIDENED LEFT INFERIOR ALVEOLAR CANAL**
FIGURE 10B	**CORTICAL DESTRUCTION OF LEFT INFERIOR ALVEOLAR CANAL**
FIGURE 11	**CORTICAL DESTRUCTION OF RIGHT MENTAL FORAMEN**
FIGURE 12	**SUPERO-LINGUAL DISPLACEMENT OF MANDIBULAR RIGHT 2ND MOLAR**
FIGURE 13A	**WIDENING OF PERIODONTAL LIGAMENT SPACE**
FIGURE 13B	**LOSS OF LAMINA DURA AND DESTRUCTION OF PERIODONTAL LIGAMENT SPACE (FLOATING TEETH)**

LIST OF TABLES

LIST OF CHARTS

ABSTRACT

TITLE: CBCT Analysis of Patients with Malignancy Involving Mandible-A Cross-sectional Descriptive Study.

BACKGROUND: Detecting presence of invasion of bone and finding effect on surrounding structures is important from diagnosis, treatment planning and prognosis point of view. Conventionally Multidirectional CT is used to detect presence of Bone Invasion in cases of Malignancy involving mandible. Recently CBCT is found to be more sensitive in detecting bone invasion in mandible. In addition CBCT provides advantage of radiation safety, Economic superiority and resolution superiority over MDCT. This study was conducted to assess the CBCT Features of malignancy involving mandible and find association of radiological features with clinical and histopathological features.

AIM: The Aim of this study is to evaluate Cone Beam Computed Tomography in analysis of Patients of Malignancy involving mandible

OBJECTIVE: Objective is to Interpret Cone Beam Computed Tomography changes in axial, coronal, sagital and three dimensional images of Malignancy involving mandible., to Associate Imaging feature with Clinical Features, to Associate Imaging feature with other Imaging features and to Associate Imaging feature with Histopathological diagnosis.

METHODOLOGY: Total 30 patients reporting to the Department of Oral Medicine and Radiology were included in the study, based on inclusion and exclusion criteria. Patients with complaints and Clinical features suggestive of Malignancy of the mandible were assessed with CBCT after which incisional biopsy was performed to get a confirmatory final diagnosis based on the histopathological features. The patients who were histopathologically confirmed to have bone invasion were then taken up for the evaluation with the CBCT scans already taken.

RESULT: The study showed maximum cases (35%) with invasion in relation to Right Posterior Alveolus. Spread of invasion was more than clinical limits of the lesion. Spread of bone invasion in mandible was faster in antero posterior direction than in supero inferior direction. The Erosive pattern was found exclusively in lesions presenting as Ulceroprolifearative growth, Cases of verrucous presentation had mixed pattern, Lesions presenting as ulcer had infiltrative pattern. 27% patients had pathological fracture, amongst these cases out of which 75% were females. All cases presenting as ulcerative lesion had IA Canal perforation present. 100% of cases with infiltrative invasion had cortical destruction of IA Canal and 54% of mixed invasion lesion had IA Canal intact. 36% teeth had loss of lamina dura, PDL Space was widened in 61% of cases and Tooth displacement was found in 22% of case. Following CBCT examination all the cases were graded as Stage IV in TNM staging.

CONCLUSION: In this study it was found that Spread of invasion is found to be more extensive than clinical limits and is more in Anteroposterior direction than superoinferiorly direction. Lesions presenting as Endophytic growth were aggressive in terms of bone invasion. There was no association between Histopathological feature and CBCT Features.

KEYWORDS: Cone Beam CT, Erosive bone invasion, Infiltrative Bone Invasion, Mandible, Mixed Bone Invasion, Oral Cancer, Squamous Cell Carcinoma.

INTRODUCTION

Cancer is the uncontrolled growth of abnormal cells in the body. Oral cancer is a disease of antiquity. Sushruta Samhita, a Sanskrit treatise of surgery, gives a description of oral cancer. The aggressiveness to spread locally involving surrounding structures causes disfigurement, affects function, and leads to physical and psychological discomfort ultimately affecting quality of life.

Oral cancer is a result of a multistage process from normal to dysplastic lesions and ultimately to carcinoma. It is a disease of increasing age, with approximately 95% of cases occurring in people older than 40 years. The age related incidence suggests that time dependent factors results in initiation and progression of genetic events that results in malignant change. The incidence of oral cancer is clearly age related which may reflect declining immune surveillance with age, time for accumulation of genetic changes and duration of exposure to initiators and promoters[1, 2]. Oral cancer is a broad term that includes various malignant diseases that present in the oral tissues. Oral squamous cell carcinoma is the most common of all, representing up to 80-90% of all malignant neoplasms of the oral cavity, particularly in the mandible, with more than 300 000 new cases diagnosed each year worldwide[3,4].

Oral cancer is a global health problem with increasing prevalence and mortality rates. It is the sixth most common cancer in the world. Worldwide, the annual incidence exceeds 3,000,000 new cases. Oral cancer accounts for 2% cancer death in males and 1% in females. Majority of oral cancers involve tongue, oropharynx and floor of the mouth. The lips, gingiva, dorsum of the tongue and palate are less common sites Head and neck malignancies comprise 3–5% of all malignancies in worldwide. In India, Oral cancer accounts for 50–70% of total cancer

mortality. It is the sixth most common cancer worldwide. Almost 70% of these patients have advanced stage disease at the time of initial diagnosis[1, 5].

The increased prevalence of the oral cancer in the subcontinent of India goes parallel with increased use of smoking, use of smokeless tobacco, alcohol, spicy food and lack of fruit or fiber intake, and neglected oral health and hygiene. Cancer of floor of mouth and tongue are common in western countries as compared to Indian subcontinent, where the cancers of gingivobuccal sulcus, tongue, and buccal mucosa are common due to placement of tobacco quid under the tongue, under the buccal mucosa and under the lip. Tobacco and alcohol are strong synergistic effects or oral cancer. There are strong synergistic effects on oral cancer risk when a person has both the habit of smoking & drinking, tobacco usage including smokeless tobacco and excessive intake of alcohol which is estimated to account for about 90% of oral cancers [3, 4].

Approach to deal with Oral cancer goes through sequential series of History recording, clinical examination, Imaging, Investigations, curative treatment and Palliative care. All components of this series being equally important, Imaging is a Corner stone due to its role in Diagnosis, Tumor staging, Treatment planing and Post treatment surveillance. For Oral cancer, rapid growth may occur even though there are no previous clinical signs.[6] For this reason also clinical examination must be complemented by radiological examination for the assessment of size, thickness and depth of the tumour as well as the degree of bone tissue invasion[7, 8]. This bone tissue invasion detection, cortical or medullary, is indicative of a T4 tumour stage. At this stage, the 5 year survival rate is close to 50%, whether treatment is surgical resection (47% survival) [9] or chemotherapy (56% survival) [10]. For this reason, detection of bone tissue invasion significantly improves patient prognosis.

Imaging techniques used to detect bone invasion includes use of Intraoral Radiography, Panoramic radiography, computed tomography, nuclear scintigraphy, magnetic resonance imaging. Existing imaging techniques have been adapted to allow for detection of bone tissue invasion. For example, use of gadolinium-diethylenetriaminepentaacetate (Gd-DTPA) [11] as a contrast medium in MRI, reduction of artefacts in CT[12] and the combined use of imaging tests such as positron emission tomography (PET)/CT[13] and SPECT/CT[14].New technologies that permit assessment of bone tissue invasion include Ultrasonography [15], single photon emission CT (SPECT) scintigraphy[16] and cone beam CT (CBCT) [17].

Cone Beam Computed Tomography (CBCT) has been an interesting development in the field of dentistry or dental radiology per say. It has allowed clinicians to view the hard tissues of the head and neck with greater ease as the equipment in question is smaller to fit in a dental office or institution, requires a smaller support staff, is easy to operate and acquire images from and all this at a fraction of the radiation dose of MDCT. This great new technology made everyone sit up and take notice, but as is usually seen whenever a new technology comes up is that, the technology precedes the knowledge. Very little information is available as to how this great technology can be put to best use to help in diagnosis and treatment planning of conditions of the head and neck.

Bony Invasion secondary to Oral cancer present with peculiar and interesting clinical and radiological features. The site, extent and pattern of the invasion, its size, cortical plate perforation or periosteal reaction, the internal structure of invaded bone, encroachment of the adjacent proximal structures and Effect on Periodontium form important radiological aspect of these lesions. These features could be evaluated with currently used modalities mentioned above, but a CBCT comes up as an interesting alternative with lower radiation dose and easy setup being one of the major advantages. Reviewing the maxillofacial structures in all

perspectives reveal extent and pattern of invasion which may enhance detection of invasion, staging and treatment planing.

Once a volume of data has been acquired and stored by CBCT, this data can be reformatted or realigned in any way the diagnostician requires. This allows the area of interest to be viewed clearly without any superimposition with other neighbouring structures and hence helps in its assessment from all perspectives.[18]

AIM:

The Aim of this study is to evaluate Cone Beam Computed Tomography in analysis of Patients of Malignancy involving mandible

Objective:

1.To Interpret Cone Beam Computed Tomography changes in axial, coronal, sagital and three dimensional images of Malignancy involving mandible.

Including:

A. Site of Invasion
B. Size of Invasion(mm)
C. Extent of Invasion
D. Pattern of Invasion
E. Periphery of the lesion
F. Internal structure of the Invasion
G. Effect on Teeth and Periodontal Structures
H. Effect on Inferior alveolar Nerve canal
    a) Cortex of canal
    b) Width of canal
I. Effect on Mental Foramen
J. Effect on periosteal cortex of mandible
    a) Buccal Cortex
    b) Lingual cortex
    c) Inferior border of mandible

2. To Associate Imaging feature with Clinical Features

3. To Associate Imaging feature with other Imaging features

4. To Associate Imaging feature with Histopathological diagnosis.

REVIEW OF LITERATURE

ORAL CANCER

HISTORICAL BACKGROUND

Earliest description of cancer can be found in scriptures dating back to medieval era. The first description of cancer is present in The Edwin Smith Papyrus, a copy of part of an ancient Egyptian textbook on trauma surgery written in 1600BC. In Indian scriptures, Sushruta Samhita, a Sanskrit treatise of surgery written by Acharya Sushruta in 600BC gives a description of oral cancer.

The origin of the word cancer is credited to the Greek physician Hippocrates (460-370 BC), who is considered the "Father of Medicine." Hippocrates used the terms carcinos and carcinoma to describe non-ulcer forming and ulcer-forming tumors. In Greek, these words refer to a crab, most likely applied to the disease because the finger-like spreading projections from a cancer called to mind the shape of a crab[19].

EPIDEMIOLOGY

Traditionally, the term 'oral cancer' is employed to connote both oral cavity cancer and oropharyngeal cancer. However, these are different clinical entities and in contemporary practice often have different etiologies and are frequently managed differently. According to American Joint Committee on Cancer (AJCC) and the Union for International Cancer Control (UICC) in the tumor-node-metastasis (TNM) staging classification squamous cell carcinomas of the oral cavity includes lesions originating from the mucosal lip, anterior two-thirds of the tongue (oral tongue), buccal mucosa, floor of mouth, hard palate, lower and upper alveolus and gingiva, and the Retromolar trigone[20].

Term Oral cancer is comprised of a heterogeneous group of cancers that arises from different parts of the oral cavity associated with different predisposing factors, prevalence, and treatment outcomes. It is the sixth most common cancer worldwide with an annual incidence of over 300,000 cases. It is the sixth most common cancer reported globally with an annual incidence of over 300,000 cases, of which 62% arise in developing countries. There is a significant difference in the incidence of oral cancer in different regions of the world, with the age-adjusted rates varying from over 20 per 100,000 population in India, to 10 per 100,000 in the U.S.A, and less than 2 per 100,000 in the Middle East[21]. In comparison with the U.S. population, where oral cavity cancer represents only about 3% of malignancies, it accounts for over 30% of all cancers in India. The variation in incidence and pattern of oral cancer is due to regional differences in the prevalence of risk factors[22].

According to GLOBOCAN 2012, a survey carried out by International agency for research on Cancer in association with World Health Organization, Lip and Oral Cavity cancer, ranks 11th amongst all cancers in men worldwide. It does not feature in top 15 cancers list for Women in world. Incidence, Mortality, 5 Year prevalence for men and women in world are 2.7%, 2.1%, 3.1% and 1.5%, 1.3%, 1.4% respectively. In an Indian scenario, Lip and Oral Cavity cancer ranks 2nd amongst all cancer in men, and 5th in women. Incidence, Mortality, 5 Year prevalence for men and women in India are 11.3%, 10.2%, 12.6% and 4.3%, 4.8%, 3.1% respectively. In South-east Asia, India ranks first in Incidence and prevalence of Lip and Oral cavity Cancer[23].

Incidence of Oral cancer in India is associated with increased consumption of smoking and smokeless Tobacco[24]. Site of involvement is also associated with habits as obvious by Cancer of floor of mouth and tongue being more common in western countries as compared to Indian subcontinent, where the cancers of gingivobuccal sulcus, tongue, and buccal mucosa are common due to placement of tobacco quid under the tongue, under the buccal mucosa and

under the lip [3, 4]. Gabriel et al. in their study to determine the effects of smoking in the antioxidant level in serum, found that chronic smoking lowers the concentration of dietary antioxidants in serum. So from his observation he suggested that smoking as the risk factor for oral cancer[25].

More than 90% of cancer of the oral cavity and oropharynx are squamous cell carcinomas (SCC) of the lining mucosae. Relatively rare neoplasms also arise in minor salivary glands and soft tissues[26].

CLINICAL PRESENTATION

Oral cancer is comprised of malignancies arising from the mucosal lip, anterior two-thirds of the tongue (oral tongue), buccal mucosa, floor of mouth, hard palate, lower and upper alveolus and gingiva, and the Retromolar trigone[20.]

OSCC may appear in any location, although there are certain areas in which it is more commonly found. The most common locations are the tongue and the floor of the mouth, mainly in Western countries; it occurs in over 50% of cases. Other areas of involvement are the buccal mucosa, retromolar area, gingiva, soft palate and, less frequently, the back of the tongue and hard palate. The lip is involved more frequently in some geographic areas[27-31].

Hirata et al. in their study of 478 carcinomas of the oral cavity performed between 1947 and 1970 found that, excluding the lip, 40% of tumours were located on the tongue and 33% on the floor of the mouth[27].

Oliver et al. in a review of 92 cases, found that the lateral and ventral surfaces of the tongue were the most border of the tongue and the floor of the mouth[28], with extension to the soft palate and tonsillar is the area of highest risk of developing cancer[29, 30]. Pattern of Site of involvement in Oral cavity in India appears to be different than western world.

Sadaksharam Jayachandran did an epidemiological study of oral cancer and pre cancer of 200cases in a tertiary referral centre in India in which 71 lesions (36%) were present on Buccal Mucosa, 31 lesions (16%) were on Tongue, 28 lesions (14%) were on alveolar mucosa, 23 were on the floor of the mouth(11%), 13 were on the Palatal Mucosa (6%), 13 were on the Retromolar trigone (6%), lip (6%) and gingiva (5%). Buccal Mucosa was clearly the predominately affected site among the 200 patients[1]. This is likely to be related to the different habits associated with Indian carcinomas. In India, a quid composed of tobacco, betel nut, and lime is in direct contact with the buccal tissue. In western world, the effects of cigarette smoke and alcohol would be expected to be more diffuse as these substances pass through the channel system. In support of this difference is the greater prevalence of buccal mucosa carcinoma among pipe and cigar smoker as compared to cigarette and alcohol users[29].

Spectra of clinical presentation of OSCC range from an Ulcer to Ulceroprolifearative growth. It might present as a flat lesion, an exophytic growth or an endophytic growth. The clinical presentation of OSSC is so characteristic in advanced stages that there is usually clear suspicion of malignancy. In contrast, it is quite possible in early stages to make the wrong diagnosis. It is always necessary to establish the diagnosis by a biopsy and histopathological examination, because the clinical characteristics alone are insufficient. Surface of the lesion can range widely presenting as Granular, Fissured, mixed or Smooth surface. In a study by Mashberg et al., Granularity was the predominant characteristic of the surface (58%), whereas 18% of lesions were fissured, 17% mixed, and 6% smooth[29]. Clinical presentation of the early malignant lesions is usually in the form of an erytholeukoplastic lesion. It consists of red or red and white areas with a slight roughness and is well-demarcated. The elasticity of the soft tissue changes to a harder sensation on palpation ("induration"). There is often no pain, but there may be some discomfort. In advanced stages the classic features of oral

malignancy include ulceration, nodularity and fixation to underlying tissues. The ulceration has an irregular floor and margins, and is elevated and hard on palpation. When the lesion is large the patient often has severe pain, radiating from the lesion to the ipsilateral ear. In these advanced stages, exophytic tumours with warty surfaces, poorly defined boundaries, and hard to palpation may be seen. Less commonly they may appear only as paraesthesia or numbness of the chin. Others manifest with delayed healing after a dental extraction, or sometimes a lump with abnormal supplying blood vessels, dysphagia or weight loss[30-36].

OSCC lesions have a variable size and can range from a few millimetres to several centimetres in the more advanced cases. The initial lesions are usually asymptomatic as they are small. Mashberg et al. reported a series of 102 asymptomatic OSCCs where 17% of the lesions were smaller than 2 cm (T1) [29].

Other authors such as Brandizzi et al. in their 274 OSCC cases, found 29% under 2 cm, 46% between 2 and 4 cm and 18% with lesions greater than 4 cm[37]. Martinez-Conde et al in a retrospective study of 40 patients with OSCC in stage I and II found that the average diameter of the lesion was 2.6cm[31].

Mashberg et al. also found a relationship between the size of the lesions and ulceration, bleeding, and lymphadenopathy. T3 and T4 lesions were more frequently fissured than smaller cancers. 64% of T1 lesions were ulcerated as compared to 92% of T2-T4 lesions. 53% were elevated more than 1 mm, whereas induration and bleeding were reported, respectively, in 89% and 41% lesions. Lymphadenopathy was present in 42 out of 93 cases and was less frequent among smaller lesions. In their study no T1 lesions had N2- N3 related nodes, as compared to 16 out of 77 (2 1 %) larger T2- T4 lesions[29].

Vallecillo Capilla et al. reported on 216 patients with oral squamous cell carcinoma studied over a period of five years. They found that the factors most associated with mortality were:

location in the gingiva, in the trigone, large size (T3-T4), and lymph node involvement (N2a-N2b) [32].

In a study conducted by Cuffari L et al. Pain was a common symptom in oral cancer patients, representing 30-40% of their main complaints[38]. Jainkittivong et al. found that swelling and/or pain were the first signs or symptoms in the 342 (52.6%) OSCC patients studied[39]. Other authors reported that the main symptoms were ulceration and swelling , followed by pain, bleeding, decreased mobility of the tongue, dysphagia and paraesthesia. Gorsky et al. reported a series of patients with OSCC of the tongue, finding that the main symptom was pain on the tongue (66.5%), while 29% had a lump on the tongue. Symptoms such as ear pain, voice changes, dysphagia, and cervical tumours were more common in tumours at the tongue base[40].

Although pain is the main symptom, it usually arises only when the lesions have reached a remarkable size, and is the time when the patient requests medical assistance. Thus, early carcinomas often go unnoticed because they are asymptomatic. In later and larger lesions, symptoms may vary from mild discomfort to severe pain, especially on the tongue[41]. Other symptoms include ear pain, bleeding, mobility of teeth, problems in breathing, difficulty in speech, dysphagia and problems using prosthesis, trismus, and paraesthesia. In some locations, such as the tongue or the floor of the mouth, pain can arise early on. In the case of OSCC of the tongue, the tongue's movement against the teeth causing more discomfort. In contrast, carcinomas of the lip and buccal mucosa only show intense pain at advanced stages. Occasionally patients may present with cervical lymphadenopathy without any other symptoms. In terminal stages, patients may develop skin fistulas, bleeding, severe anaemia and cachexia[42].

DETECTION OF BONE INVASION IN ORAL CANCER

Oral cancer frequently invades the bone of the mandible, necessitating surgery to the bone. Five possible routes of entry into mandible[43] are:

(1) At the site of primary development of the carcinoma

(2) Through the occlusal surface

(3)Through the mental foramen

(4)Through the lower border by direct spread from lymph nodes

(5)From the mucosal covering through the periosteum

McGregor and MacDonald reported on the routes of entry of tumor into the mandible and they suggested that there was a consistent pattern of invasion through the alveolar crest that provided sound pathologic support for conservative upper border resection of the mandible in appropriate cases. In their study Squamous cell carcinoma entered the mandible through the occlusal surface in 93.2% cases and, in 9 of their 41 cases, Squamous cell carcinoma also spread through the lingual plate. Only in three cases (6.8%) did the pattern of spread involve the bone differently. Squamous cell carcinoma was found to enter the medullary cavity through the upper border of the mandible, either through the occlusal ridge alone or in combination with penetration of either the buccal or lingual plates. These findings therefore confirm the importance of cortical bone defects in the edentulous alveolus as a route for direct spread of tumor into the mandible[44].

The surgeon is faced with the dilemma of ensuring adequate removal of tumor, while trying to limit the difficult functional and cosmetic problems resulting from removal of mandibular bone. If the full thickness of the mandible is resected, these problems can be severe, but many

surgeons have advocated such resection, if the mandible is involved at all by tumor. Because spread of squamous cell carcinoma to the mandible is largely through the upper border, the principle of partial resection of the mandible to include the upper border would seem to be acceptable on pathologic grounds providing the extent of tumor spread within the bone is not sufficiently advanced that segmental resection is required[45].

Both the extent and pattern of bone invasion is associated with the outcome. Regarding the extent of bone invasion, the supero-inferior extent should be detected precisely on the diagnostic imaging, because it is one of the determinant factors for the surgeons to choose between a rim and a segmental resection of the mandible as the surgical method. **Eiji** Nakayama classified the pattern of bone invasion on the diagnostic images is into three types: The invasive pattern was defined as bone destruction with an irregular and ill-defined margin accompanied with bony spicules or isolated fragments. The erosive pattern showed U-shaped or scalloped bone destruction to the medullary bone with a smooth and well-defined margin, and no isolated bony spicules. The mixed pattern was defined as bone destruction with an irregular margin and intermediate features between the erosive and invasive pattern [46], [47].

Squamous cell carcinomas of the oral cavity that are mobile on clinical examination may, depending on their deep extent, be locally excised. However, lesions that are fixed to the mandible often require some form of mandibulectomy. The type of mandibulectomy is predicated on the presence of tumor invasion of the underlying bone. Tumors that are fixed to the periosteum and do not invade the mandible may be resected by a marginal (rim) mandibulectomy; tumors that erode bone are upstaged to T4 and treated with segmental mandibulectomy[48, 49]. Hence the assessment of invasion of the mandible is integral in patients with carcinomas of the oral cavity because the surgical procedure is influenced by the presence and extent of bone involvement.

Imaging plays an exciting, vital and critical diagnostic role in detecting invasion in mandible, and has brought revolution in medical field with the invention of newer rapidly expanding wide array of imaging modalities. Recent decades have seen the development of CT, MRI, nuclear medicine, and ultrasonography, imaging modalities that have revolutionized dental and medical diagnosis. Various imaging modalities have been used to predict mandibular invasion by squamous cell carcinoma of the oral cavity when attempting to determine whether patients are candidates for mandibular-sparing procedures.

Different preoperative investigation may be applied alone or in combination to assess mandibular involvement. Intraoral Radiography (IR), panoramic radiography (PR), Computed Tomography (CT), Cone Beam Computed Tomography (CBCT), Bone scintigraphy, Single photon emission computed tomography (SPECT) and Magnetic resonance imaging (MRI) have all been used to predict mandibular invasion by SCC of the oral cavity. PR, IR with Periapical projection and CT are generally used as imaging methods for detecting the bone invasion. CT clearly represents bony changes of the mandible due to carcinoma if the CT images fill the following conditions:

1. thin scanning widths are chosen;
2. the scanning plane is selected parallel to the mandibular plane in order to eliminate any artifacts caused by metallic dental restorations;
3. super high resolution CT images of the optimal bone window mode are obtained

Three types of diagnostic imaging (PR, PR + IR, and CT) were evaluated by Eiji Nakayama using the receiver operating characteristic (ROC) analysis. The area under ROC curves was used as the index of diagnostic accuracy in the study. As the result of this study, the accuracy of diagnostic images regarding the detection of a slight bone invasion within the alveolar bone ranged from 77% to 88%, and that accuracy was lower than that of the detection of bone

invasion beyond the alveolar bone (83-89%), and that of bone invasion into the mandibular canal (91-94%) On the other hand, the accuracy of PR and PR + IR is equal to that of CT regarding the detection of bone invasion into the mandibular canal, and hence, PR would be suitable for the initial screening modality to survey the bone invasion into the mandibular canal and determine the T classification, because it is generally available at most hospitals, and more economical than CT[50, 51].

Kawano et al. compared the depth of tumor invasion of 21 Mandibular cancer on the cross-sectional (bucco-lingual) decalcified HE stained sections with that on the PR. They concluded that the depth of tumor invasion on PR coincided with that on HE stained section in many cases. However, in some cases with infiltrative bone invasion, the depth of tumor invasion on PR were underestimated compared with that on the HE stained section. In these cases, tumor infiltrated into the deep bone marrow without destroying the bone trabecula, and the fact is the reason of the underestimation on PR[52].

Some discrepancies occur between the pattern of bone destruction on the conventional radiograph images (PR, IR) and the histological findings. Ohba et al. described one case which they classified as moth-eaten on PR findings, but which was shown histologically to be erosive. Reviewing the radiograph, they found that they had misdiagnosed the residual normal trabecular bone around the tumor as bony spicules within it[53]. Totsuka et al. stated that 7 out of 24 cases, which they classified as invasive pattern on the conventional radiographs, histologically showed an erosive pattern, while 2 out of 14 cases, classified as erosive pattern on the conventional radiographs, were histologically invasive. Iwaki also reported a similar discrepancy[54]. This discrepancy might be caused by the fact that the conventional radiography is two-dimensional superimposed image, and lacks the information about the bone destruction at the buccal and lingual cortex. If a diagnostic image detects the findings of bone destruction at not only the supero-inferior and medio-distal aspects of the

bone, but also the bucco-lingual condition of the bone, the discrepancy might have been solved. Therefore, CT is suitable for determining the pattern of bone destruction because the CT image provides three-dimensional information of bone destruction including the buccal and lingual cortex of the mandible. From the above-mentioned two points of view, Eiji Nakayama investigated the association between the pattern of bone destruction based on the CT and the outcome of the patients compared with the association based on the PR. As a result, the pattern of bone destruction based on the CT findings was closely associated , but in contrast, the pattern of bone destruction based on the PR findings was not associated with the cumulative survival rate. In conclusion, the pattern of bone destruction based on the CT is a more important factor in determining the prognosis than that on the PR. From this result, we considered that the CT findings might reflect the histologic appearance more closely than the PR findings[47].The diagnostic criteria of CT Mandibular cortical invasion is a Defect of the cortical bone adjacent to the tumor mass, of CT Bone marrow involvement is Trabecular disruption contiguous to the cortical defect and Inferior alveolar canal involvement is Bone marrow involvement reaching the inferior alveolar canal[55].

Magnetic resonance imaging (MRI) is generally valuable for the diagnosis of malignant tumors, and therefore, it is expected to be useful for assessing bone invasion of the mandible. Van Cann et al. reported that some parameters of dynamic contrast enhanced MRI could discriminate the tumor with medullary invasion from the tumor without it in oral cancer[56]. However, several study shows that magnetic resonance imaging had more false positives and frequently overestimated the extent of tumor invasion because of the high intensity due to the edematous or inflammatory changes at the soft tissue adjacent to the tumor, and therefore, the accuracy of MRI is not thought superior to that of CT concerning the bone invasion of oral cancer[57-58]. Campbell et al showed that a positive predictive value of MR imaging was 67% for evaluating mandibular invasion[59]. Similarly, Chung et al reported that a positive

predictive value of MR imaging was <70% for evaluating cortical invasion and <50% for medullary invasion[60]. A Possible cause false-positive results with MR imaging is Chemical shift artifact. Chemical shift refers to small changes in resonant frequency due to different molecular environments of nuclei. In case of detection of Invasion Chemical shift is due to the differences between resonance frequencies of fat and water. To confirm that chemical shift artifact might obscure the lingual cortex of the midline mandible, MR imaging was performed in a normal volunteer by Imaizumi A et al. In this study, the mandible was imaged by the 3 different methods of T1-weighted spin-echo sequence. The study showed that the lingual cortex was lost on the ordinary T1-weighted image, whereas it remained intact when phase-and frequency-encoding directions were swapped or when fat saturation pulse was used. These findings confirmed the hypothesis[55]

The diagnostic criteria of MRI Mandibular cortical invasion is a Defect of the cortical bone adjacent to the tumor mass, of MRI Bone marrow involvement is Abnormal signal intensity of bone marrow contiguous to the cortical defect and Inferior alveolar canal involvement is Bone marrow involvement reaching the inferior alveolar canal[55].

Positron-emission tomography (PET) with Fluorine 18 fluorodeoxyglucose (FDG) is also expected to be useful for assessing bone invasion because FDG accumulates well at the malignant tumor[47]. However, Goerres et al. reported that the assessment of cortical erosion with contrast-enhanced CT and the CT information from PET/CT were the most reliable methods for detecting bone invasion, and FDG uptake seen on PET/CT images did not improve identification of bone infiltration. This report indicates that CT is essentially superior to PET alone concerning the detection of bone invasion[61]. It is likely, because FDG accumulates well at not only the lesion of malignant tumor but also the inflammatory lesion and the spatial resolution of PET is not high[62].

The diagnostic criteria of SPECT Bone invasion analysis: any increased tracer uptake at the tumour site correlating with the CT-morphologically visible tumour extension close to the mandible[55].

Cone Beam Computed Tomography (CBCT) is an intensely developed diagnostic tool. The usefulness of CBCT in detecting osteolysis has been documented. CBCT is more accurate than panoramic radiography and comparable to MRI, CT and bone scintigraphy. Moreover, CBCT is increasingly used by dentists in everyday practice which can result in an improved detection of oral cancers. However, CBCT is limited by a poor assessment of soft tissues.

S Uribe et al did a systematic review of studies in MEDLINE, SciELO and ScienceDirect, published between 1960 and 2012, in English, Spanish or German, which compared detection of mandibular bone tissue invasion via different imaging tests against a histopathology reference standard .Evidence showed that all tests have a high diagnostic accuracy for detection of mandibular bone tissue invasion by SCC, with sensitivity values of 94% (MRI), 91% (CBCT), 83% (CT) and 55% (panoramic radiography), and specificity values of 100% (CT, MRI, CBCT), 97% (PET/CT) and 91.7% (panoramic radiography)[63].

Linz C et al evaluated cone beam computed tomography (CBCT) for detecting bone invasion in comparison to standard imaging techniques. A total of 197 patients with diagnoses of oral cancer underwent CBCT as part of preoperative staging between January 2007 and April 2013. The sensitivity, specificity, and accuracy of CBCT were compared with panoramic radiography (PR), multi-slice computed tomography (CT) or magnetic resonance imaging (MRI), and bone scintigraphy (BS). Comparison of CBCT and BS (84.8% and 89.3%, respectively); and of CBCT and CT/MRI (83.2%), showed comparable accuracy. CBCT was significantly superior to PR. In detecting bone invasion, CBCT was Significantly more accurate than PR and was comparable to BS and CT/MRI[64].

In a comparative study between CBT and CT in detection of Lesions of Maxillofacial skeleton, CBCT was superior to MDCT in detecting thinning and/or perforation of buccal cortical plate and displacement of teeth[65].

Cone Beam Computed Tomography (CBCT)

It is a recent innovation in field of technology that has achieved the rapid acceptance in general, particularly in dentistry despite its current relatively high price when compared with alternative imaging methodologies. Craniofacial CBCTs were designed to counteract some of the limitations of the conventional CT scanning devices[66].

The object to be evaluated is captured as the radiation source falls onto a two-dimensional detector. This simple difference allows a single rotation of the radiation source to capture an entire region of interest, as compared to conventional CT devices where multiple slices are stacked to obtain a complete image[67]. The cone beam also produces a more focused beam of x-ray and significantly less scatter radiation compared to the conventional fan-shaped CT devices, and this considerably increases the X-ray utilization and reduces the ability of X-ray tube required for volumetric scanning [68].

It has been reported that the total radiation dose is approximately 20% of conventional CTs and equivalent to a full mouth periapical radiographic exposure[69].

These component innovations are significant and allow the CBCT to be less expensive and smaller. Furthermore, the exposure chamber (i.e. head), is custom built and reduces the amount of radiation. The images are comparable to the conventional CTs and also may be displayed as a full head view, as a skull view or regional components depending upon the field of view.

Robb RA reported the use of first CBCT scanner for angiography among at Mayo Clinic in 1982 [70]. Later, several other systems were developed specifically for angiography. Fahrig et al. developed a CBCT system based on an image intensifier and C-arm for use in angiography [71]. Saint-Felix et al developed a CTA CBCT system based on the gantry of a conventional CT scanner which reconstructs vasculature from a set of digitally subtracted angiography (DSA) images [72].

CBCT systems are also used for radiation therapy planning, in mammography, and interoperatively for otorhinolaryngological surgery. CBCT system for radiotherapy guidance based on an amorphous silicon (a-Si:H) flat-panel detector was decelopd by Jaffray and Siewerdsen[73].

In late 1990s only that it has become possible to create clinical systems that are both inexpensive and small enough to be used in the dental office. The first commercial CBCT system for oral and maxillofacial imaging was the NewTom (Quantitative Radiology, Verona, Italy), which was first approved by the Food and Drug Administration (FDA) in April 2001, and is currently in its fourth generation as the NewTom VG. Since that time numerous additional systems have been approved or are in development [67].

Presently, the available CBCT equipment differs in size, possible settings, area of image capture (field of view), and clinical usage.

CBCT has application in several diagnostic areas, such as implant treatment, oral surgery, endodontic treatment, and temporomandibular joint imaging. The great advantage of this technology is that offers 3-dimensional (3D) imaging of dental structures and provides clear images of highly contrasted structures, such as bone. In comparison to the conventional computed tomography, CBCT technology in clinical practice has significant advantages such as minimization of the dose of radiation to the patient, accuracy of image, rapid scanning

time, lesser image artifacts, chair-side image display, high spatial resolution and real-time analysis[74].

It uses a divergent or cone-shaped source of ionizing radiation and a two dimensional area detector fixed on a rotating gantry to acquire multiple sequential projection images in one complete scan around the area of interest[75].

Four technological factors have contributed to make this possible:

1) The development of compact high quality flat panel detector arrays,

2) Reduction in the cost of computers capable of image reconstruction,

3) Development of inexpensive X-ray tubes capable of continuous exposure

4) Limited volume scanning (e.g., head and neck), eliminating the requirement of sub second gantry rotation speeds[76].

THIS TECHNOLOGY HAS BEEN GIVEN SEVERAL NAMES INCLUDING

Dental Volumetric Tomography

Digital Volumetric Tomography

Cone Beam Volumetric Tomography

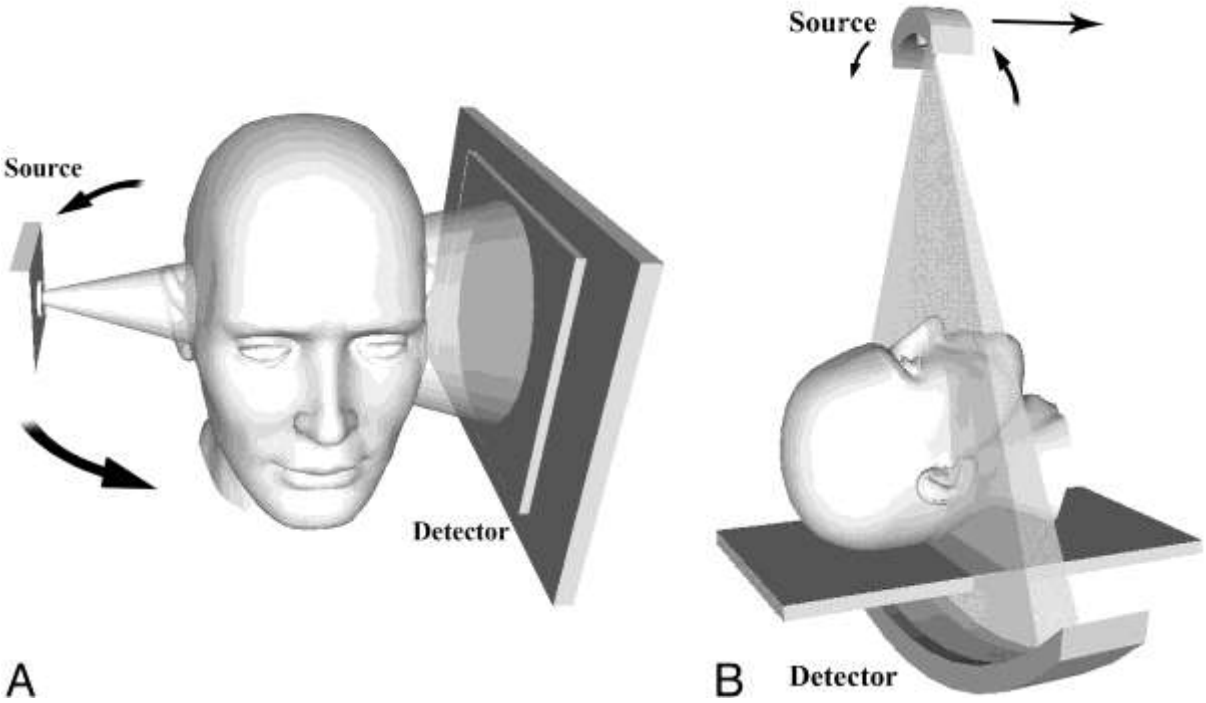
Cone Beam Computed Tomography

Dental Computed Tomography

Cone Beam Imaging

PRINCIPLES OF CONE BEAM COMPUTED TOMOGRAPHY

All CT scanners consist of an x-ray source and detector mounted on a rotating gantry. During rotation of the gantry, the receptor detects x rays attenuated by the patient. These recordings constitute ―raw data that is reconstructed by a computer algorithm to generate cross sectional images whose component picture element (pixel) values correspond to linear attenuation coefficients. CT can be divided into 2 categories on the basis of acquisition x ray beam geometry, namely fan beam and cone beam[76]. Cone beam scanners use a 2 dimensional digital array providing an area detector unlike linear detector as CT does. This is combined with a three dimensional (3D) x-ray beam with circular collimation so that the resultant beam is in the shape of a cone, hence the name ―cone beam. Because the exposure incorporates the entire region of interest (ROI), only one rotational scan of the gantry is necessary to acquire enough data for reconstruction.



Fan shaped x-ray beam in Conventional CT (B) and Cone shaped beam of x-rays in CBCT (A)

Voxel dimensions are dependent on the pixel size on the area detector. Therefore CBCT units in general provide voxel resolutions that are isotropic- equal in all three dimensions [77].

Cone beam geometry has inherent quickness in volumetric data acquisition and therefore the potential for significant cost savings as compared with CT, CBCT produces an entire volumetric dataset from which the voxels are extracted.

FIELD OF VIEW

Scanners using flat panel detectors (FPD) describe the dimensions of their cylindrical field of view‘s (FOV) as height by width (HxW). Width also can be referred to as diameter. Field of view refers to the area of the anatomy that is captured by the scan. Scanners are grouped into three categories based on their field of view.

1. Large field of view-

A scanner with large field of view will show the roof of the orbits and nasion down to the hyoid bone. Scanners with large FOV, usually a FOV height equal to or greater than 16 cm, are useful for cephalometrics and traditional orthodontic surveys.

Eg- Next Generation (Platinum) i-CAT developed by Imaging Sciences

International has a FOV of 17x23 cm.

Kodak 9500 developed by Carestream has a FOV of 18x21cm.

New Tom 3G developed by Imaging Sciences has a FOV of 20x20 cm

2. Medium field of view

Medium FOV scanners will capture the middle of the orbits down to menton vertically, and condyle to condyle horizontally. Scanners with a medium FOV are useful for panoramic radiograph and implant surveys, but not for cephalometric analysis.

Eg- New Tom 9000 by Aperio services has a FOV of 15x15x15cm I-CAT services by Imaging Sciences International have a FOV of 8x14 cm.

3. Small field of view

Scanners with a small FOV capture a user-defined region, usually symmetrical in shape. Small FOV scanners are used for implant surveys, TMJ surveys, and the localization of impacted teeth.

Eg- Kodak 9000 3D and Kodak 9000 3DC developed by Carestream has a FOV of 4x5cm

ProMax 3D manufactured by Planmeca has a FOV of 8x8cm.

Advantage of use of CBCT technology in clinical practice for maxillofacial imaging compared with conventional CT[78]:

- X-ray beam limitation: Reducing the size of the irradiated area by collimation of the primary x-ray beam to the area of interest minimizes the radiation dose.
- Image accuracy: The volumetric data set comprises of voxels which are 3D blocks of smaller cuboid structures. Each voxel represents a specific degree of x-ray absorption. The size of these voxels determines the resolution of the image. In conventional CT, the voxels are anisotropic, i.e. rectangular cubes where the longest dimension of the voxel is the axial slice thickness. In CT voxel size determined by slice pitch, a function of gantry motion. CT voxel surfaces can be as small as 0.625 mm^2, however their depth is usually

in the order of 1–2 mm. In CBCT units, voxel resolutions are isotropic i.e. equal in all 3 dimensions. This produces sub-millimetre resolution to exceed the highest grade multi-slice CT. The resolution ranges from 0.4 mm to as low as 0.125 mm.

- Rapid scan time: CBCT acquires all basis images in a single rotation. This reduces the scan time (10–70 seconds) .It is comparable with that of medical spiral CT systems. Faster scanning time usually means fewer basis images from which to reconstruct the volumetric data set. This reduces motion artifacts due to subject movement.
- Dose reduction: Published reports indicate that the effective dose of radiation of CBCT is significantly less (up to 98%) when compared with conventional fan-beam CT systems. This reduces the effective patient dose which is comparable to that of a film-based Periapical survey of the dentition or 4–15 times that of a single panoramic radiograph.

Effective dose for panoramic radiograph	:2.9–11 μSv
Effective dose for film-based Periapical survey	:13–100 μSv
Effective dose for CBCT scan	:36.9–50.3 μSV
Effective dose for CT Maxilla	:1,031–1,420 μSv
Effective dose for CT Mandible	:1,320–3,324 μSv

- Display modes unique to maxillofacial imaging: Access and interaction with medical CT data are difficult as workstations are required. Data needs to be converted and imported into proprietary programs for use on personal computers. This process is expensive and requires an intermediary stage which extends the diagnostic phase. In contrast to CT, reconstruction of CBCT data is performed by a personal computer. In addition, software can be made available to the radiologist and clinician either via direct purchase or innovative ―per use licence from various vendors (e.g., Imaging Sciences International). This provides the clinician an opportunity to use chair-side image display, real-time

analysis and MPR modes that are task specific. The CBCT volumetric data set is isotropic hence the entire volume can be reoriented to realign the patient‘s anatomic features.The cursor driven measurement algorithms allow the clinician to do real time dimensional assessment.

- Reduced image artifact: Manufacturer‘s artifact suppression algorithms and increasing number of projections results in a low level of metal artifact in CBCT images.

Specific applications CBCT in dentistry: CBCT technology has a substantial impact on the maxillofacial imaging. It has been applied to diagnosis in almost all the areas of dentistry and now its role is also expanding into treatment fields[76].

Implant site assessment

Orthodontics and Three Dimensional Cephalometrics

Temporomandibular joint

Conditions of the maxillofacial complex

Odontogenic Cysts and Tumors

CBCT DETECTION OF BONE INVASION IN ORAL CANCER

CBCT has been commercially available since 2001. Since that time dental practitioners have used it to guide implant placement, view third molar relationships to the inferior alveolar nerve, image the cleft alveolus, and view limited areas of bony pathology in the jaws[77-79].The ideal study for determining mandibular invasion by oral cancer has not been determined. A recent report has shown that panoramic radiograph, MRI, and bone scintigraphy are associated with a high false-negative rate when used to predict mandibular invasion.A

prospective study designed to determine the accuracy of available studies for predicting mandibular invasion showed that bone scintigraphy and MRI overpredict and CT and panoramic radiograph underpredict mandibular invaslon[80-81]. The use of CBCT to image oral cancer and guide surgical resection is not well reported in the literature. Traditionally the CT is commonly chosen to evaluate mandibular invasion. Cost of CT Scan is a financial burden and sometimes unaffordable by patients. The radiation dose received by the patient varies with scanner used and area imaged, but ranges from 289 to 723 micro sv [82]. Cone beam volume technology can image the bony structures of the craniofacial complex at approximately one twelfth the cost and at one sixth the radiation dose of a conventional helical CT scan. Additionally, in 2003 Hashimoto et al reported the image quality was better than conventional CT compared with CBCT with a latest model multidetector CT scanner[83]. The CBCT scanner can perform the entire scan in less than 10 seconds using the MercuRay (Hitachi, Tokyo, Japan) without subjecting the patient, who may be claustrophobic, to a longer period of time in an enclosed type conventional scanner system. When compared with plain film radiography, CBCT can image the anterior mandible more clearly, evaluate for inferior alveolar nerve involvement, and allow for visualization of a specific area of the mandible from multiple perspectives by using the volume views or rotating the images.

James Closmann and Brian Schmidt[84] in their case series of 3 cases, demonstrated use of CBCT in different scenarios. In one of their cases CBCT helped in detecting presence of Bony invasion that was missed in Conventional Radiography. In another case CBCT was used to detect bony invasion in a patient who developed allergic reaction to contrast media injected to for contrast enhanced CT. In last of their case CBCT helped in confirming intact osseous structure without bony invasion.

Studies done by Czerwonka et al[85] (2017), Hakim et al[86] (2014), Dreiseidler et al[16] (2011), Hendrikx et al[87] (2010) and Momin et al[17] (2009) to compare the ability of CBCT and CT in

detecting Bony invasion in Oral cancer have found the Sensitivity of CBCT to be superior than MDCT. Specificity of CBCT in detecting invasion varies in the studies, ranging from 60% to 100%. The reason for this discrepancy is not clear

	CT		CBCT	
	Sensitivity	Specificity	Sensitivity	Specificity
Czerwonka et al[87]	86%	68%	91%	60%
Hakim et al[88]	63%	84%	94%	59%
Dreiseidler et al[16]	80%	100%	92%	97%
Hendrikx et al[89]	-	-	91%	100%
Momin et al[17]	-	-	89%	60%

CBCT can accurately aid in Diagnosing invasion of mandible, evaluating and treatment planning and prognosis in malignant tumors of the mandible with less cost and decreased radiation to the patient relative to conventional CT.

MATERIALS AND METHODS:

The study was conducted at Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003.

The study protocol was approved by the Institutional Ethical Committee.

DURATION OF THE STUDY:

From June 2016 to November 2017

SAMPLE DESIGN:

Totally 30 cases who were diagnosed with Cancer involving Mandible based on history, clinical findings and histopathology, were included under the study. Out of total 30 patients 20 were male and 10 were Female. All were in age group of 40-70 years. The cases were selected from the Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003.

The patients who satisfied the following inclusion and exclusion criteria were selected for the study

Inclusion Criteria:

1. Patients with Histopathologically proven Malignant lesions
2. Patients with Radiological proof of Bone invasion
3. Co-operative patients
4. Age :40-70 years
5. Both genders.
6. Willing to participate in study

Exclusion Criteria:

1. Cases of recurrence
2. Cases with history of surgical excision or previous Radiotherapy
3. Patient not able to co-operate for Cone Beam Computed Tomography Scan
4. Patients without Histopathological confirmation of malignant lesion
5. Not willing to participate in study

METHODOLOGY:

Total 30 patients reporting to the Department of Oral Medicine and Radiology were included in the study, based on inclusion and exclusion criteria. All those participants were explained about the design of the study, the need for thorough clinical examination and CBCT as a part of the study. Patients who gave a signed informed consent on an institutionally approved document were included in the study. The study protocol was approved by the Institutional Ethical Committee.

Informed consent was obtained from every patient, and they were subjected to routine blood investigation and habit cessation counselling in our institution before and during the study. Complete medical history and clinical findings of all the cases were recorded in the structured Proforma prepared for the study. Patients with complaints and Clinical features suggestive of Malignancy of the mandible were subjected to a thorough History and clinical examination, details of which were entered into the structured proforma specially made for the study. CBCT for each patient was taken in Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai–600 003 after which incisional biopsy was performed to get a confirmatory final diagnosis based on the histopathological features. The patients who were histopathologically confirmed to have features of

Malignancy were then taken up for the pre- operative evaluation with the CBCT scans already taken.

Armamentarium: (Figure 1)

Examination of the patient

1) Electrically operated dental chair
2) Patient's apron
3) Disposable mouth mask
4) A pair of disposable latex examination gloves
5) Stainless steel kidney trays
6) Mouth mirror
7) Stainless steel probe
8) Tweezer
9) Gauze
10) Divider and Metallic ruler

On diagnosis of Malignancy involving mandible (Figure 3) based on History and Clinical examination, patients were subjected to CBCT Examination. CS 9300 Select (Carestream Health, Inc.) cone beam 3D extraoral imaging system was used.(Figure 2) The CBCT machine had a scanning time of 12-28 seconds (+/- 10%), voxel size 90μm to 180μm, field of view 5x5cm, 8x8cm, 10x5cm, 10x10cm and fitted with a TFT sensor. For this study, field of view of10x10cm with voxel size of 180 μm was used. Exposure parameters for the patients varied from, tube voltage 60 - 90 kV, tube current 2 - 15 mA, with a scan time of 12- 28 seconds. Routine radiation safety procedures were followed.

Patients were positioned in standing position while taking the scan. The total image acquisition time was less than 2 minutes. Radiation exposure for a Single CBCT scan was in the range 0.02 to 0.08 mSv. The radiographic exposure for patients was well below the maximum permissible dose of 2.4 mSv as per the NCRP guidelines.

The 3 D volumetric image data and the various sections were viewed in the Dental Imaging Software 6, 13, 1, 8(Copyright Carestream Health, Inc.,2013) on Hewlett- Packard HP Z220 CMT Workstation running on Windows 7 Professional Operating System (Copyright © 2009 Microsoft Corporation).

The DICOM data was analyzed on secondary reconstructed orthogonal Axial, Coronal and Sagittal slices, Oblique Slices, reformatted OPG and reconstructed 3 dimensional images. Cross sectional CBCT images were evaluated to assess the site of invasion, size of invasion (mm), Periphery of the invasion, extension of the invasion, Internal structure of the invasion, pattern of invasion, Effect on periosteal cortex, Effect on inferior border of mandible, and Effect on Teeth and Periodontal Structures. Manual tracing of the inferior alveolar canal was done using the company proprietary software to assess Effect on Inferior alveolar canal in terms of effect on Cortex of canal and Width of canal, Effect on Mental Foramen.

Clinical Features:

Clinical Examination was performed on electrically operated dental chair using sterilized instruments. All features were expressed as binary numbers or quantitative value.

(1)Presenting type:

Lesions presenting with ulcerative appearance were defined as “1”

Lesions presenting as Ulceroprolifearative growth were defined as “2”

Lesions presenting as verrucous hairlike growths were defined as “3”

(2) Site of the Lesion:

Mandible divided into 6 portions

A- Right Retromolar Region

B- Right posterior mandible (From distal surface of canine till last molar)

C- Right Anterior mandible (canine to Midline)

D- Left Anterior mandible (canine to Midline)

E- Left posterior mandible (From distal surface of canine till last molar)

F- Left Retromolar Region

In case of invasion involving more than one regions, all the invaded regions were recorded to be invaded.

(3) Associated with OSMF:

Presence of OSMF was defined as “1”

Absence of OSMF was defined as “0”

(3)Parasthesia:

Presence of Parasthesia of ipsilateral lower lip, chin region and gingiva of mandibular teeth was defined as “1”

Absence of Parasthesia was defined as “0”

(4) Size of lesion -T (Clinical)

Size of lesion <2cm (T1) was defined as “1”,

Size of lesion 2-4cm (T2) was defined as “2”

Size of lesion >4cm (T2) was defined as “3”.

(5)Regional Lymphnode involvement – N (Clinical)

Absence of regional Lymphnode metastasis was defined as N0.

Single clinically positive ipsilateral node less than 3 cm was defined as N1.

Metastasis in single ipsilateral lymph node more than 3 cm but not more than 6 cm in greatest dimension was defined as N2a.

Metastasis in multiple ipsilateral lymph nodes, none more than 6 cm in greatest dimension were defined as N2b.

Node nodes greater than 6 cm were defined as N3.

(6)Distant Metastasis –M

Absence of Distant Metastasis was defined as 0

Presence of Distant Metastasis was defined as 1.

(7)Dentition status

Presence of mobility of tooth was defined as “1”

Mobility associated with displacement of tooth was defined as “2”

Absence of tooth secondary to exfoliation was defined as “3”.

Imaging features

All the cases of clinically diagnosed cancers were subjected to CBCT evaluation. Measurements were performed and all imaging features were expressed as binary numbers or quantitative values. The CBCT images were evaluated with regard to the following aspects

(1) **Site:** (Figure 4)

Mandible divided into 6 portions

G- Right Retromolar Region

H- Right posterior mandible (From distal surface of canine till last molar)

I- Right Anterior mandible (canine to Midline)

J- Left Anterior mandible (canine to Midline)

K- Left posterior mandible (From distal surface of canine till last molar)

L- Left Retromolar Region

In case of invasion involving more than one regions, all the invaded regions were recorded to be invaded.

(2) Size(Figure 5)

Maximum Measurement in Supero-inferior Direction (A)

Maximum Measurement in Antero-Posterior Direction (B)

Ratio of Maximum Measurement in Supero-inferior Direction to Maximum Measurement in Antero-Posterior Direction (A: B)

(3) Extension of invasion (Figure 6)

When the lesion crossed the midline a score of "1" was assigned and for the lesions confined to one side of midline a score of "0" was assigned.

(4)Invasion Pattern (Figure 7)

The erosive pattern (U-shaped or scalloped bone destruction to the medullary bone with a smooth and well-defined margin, and no isolated bony spicules) was defined as "1".

The invasive or Infiltrative pattern (bone destruction with an irregular and ill-defined margin accompanied with bony spicules or isolated fragments) was defined as "2".

The mixed pattern (bone destruction with an irregular margin and intermediate features between the erosive and invasive patterns) was defined as "3".

(5) Effect on Periosteal Cortex(Figure 8)

Erosion of Periosteal Cortex was defined as "1"

Perforation of Periosteal Cortex was defined as "2"

Presence of Periosteal reaction on Cortex was defined as "3".

In cases where both cortex were involve both the involvements were recorded. In cases of both cortexes appearing to be involved in different manner, both were recorded separately.

(6) Inferior border of Mandible(Figure 9)

An intact inferior border of Mandible was defined as "0"

Discontinuity in the inferior border was defined as "1".

(7) Inferior Alveolar Canal(Figure 10)

An intact Inferior Alveolar canal was defined as "0"

Widening of Inferior alveolar Canal was defined as "1"

Cortical destruction of Inferior alveolar canal was defined as "2".

(8) Mental Foramen(Figure 11)

An intact mental foramen was defined as “0”

Erosion of Mental foramen cortex was defined as “1”

Cortical destruction of mental foramen cortex was defined as “2”

(9) Effect on Tooth and Periodontal Structure

Cases in which teeth were absent were marked with “x”

A. Displacement (Figure 12)

Absence of displacement of tooth was defined as “0”

Presence of Displacement was marked with “1”

B. Lamina Dura(Figure 13A)

Intact Lamina dura was defined as “0”

Loss of lamina dura was defined as “1”

C. Periodontal ligament space(Figure 13B)

Intact Periodontal ligament space was defined as “0”

Widening of Periodontal ligament space was defined as “1”

Complete destruction of periodontal ligament space leading to floating tooth appearance was defined as “2”

Histopathological Feature:

Lesion diagnosed as well differentiated Squamous cell carcinoma were defined as “1”

Lesion diagnosed as moderately differentiated Squamous cell carcinoma were defined as “2”

Lesion diagnosed as poorly differentiated Squamous cell carcinoma were defined as “3”.

Lesions diagnosed as Verrucous Carcinoma were defined as “4”.

PHOTOGRAPHS

FIGURE 1

ARMAMENTERIUM

FIGURE 2

CBCT MACHINE (CARESTREAM 9300 SELECT, 90 kVp, 15MA, 28S)

FIGURE 3A
ULCEROPROLIFERATIVE GROWTH
OF RIGHT ALVEOLUS AND RETROMOLAR REGION

FIGURE3B
ULCERATIVE LESION OF LFFT ALVEOLUS

FIGURE 3C
VERRUCOUS LESION OF RIGHT ALVEOLUS

FIGURE 4
MAXIMUM MEASUREMENT IN SUPERO-INFERIOR DIRECTION (A) AND ANTERO-POSTERIOR DIRECTION (B)

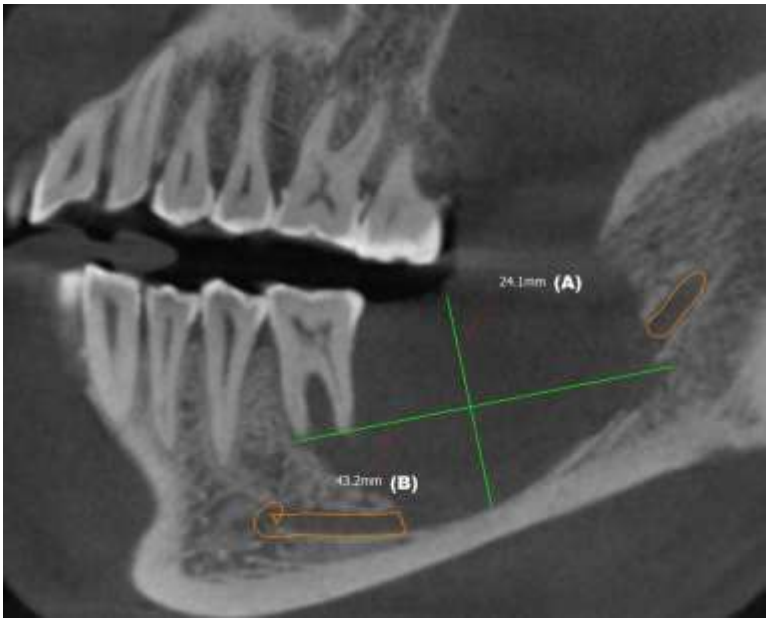


FIGURE 5

REFORMATTED PANORAMIC IMAGE SHOWING SIX SITES

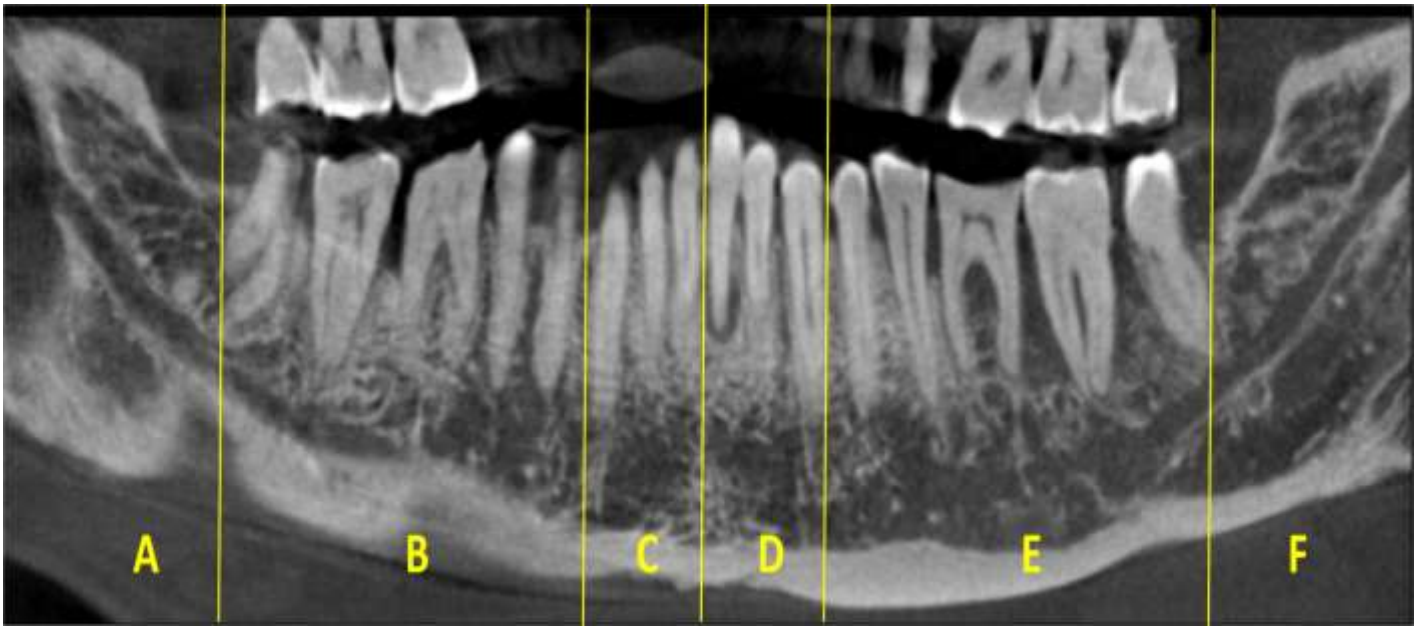


FIGURE 6

REFORMATTED PANORAMIC IMAGE SHOWING LESION CROSSING THE MIDLINE

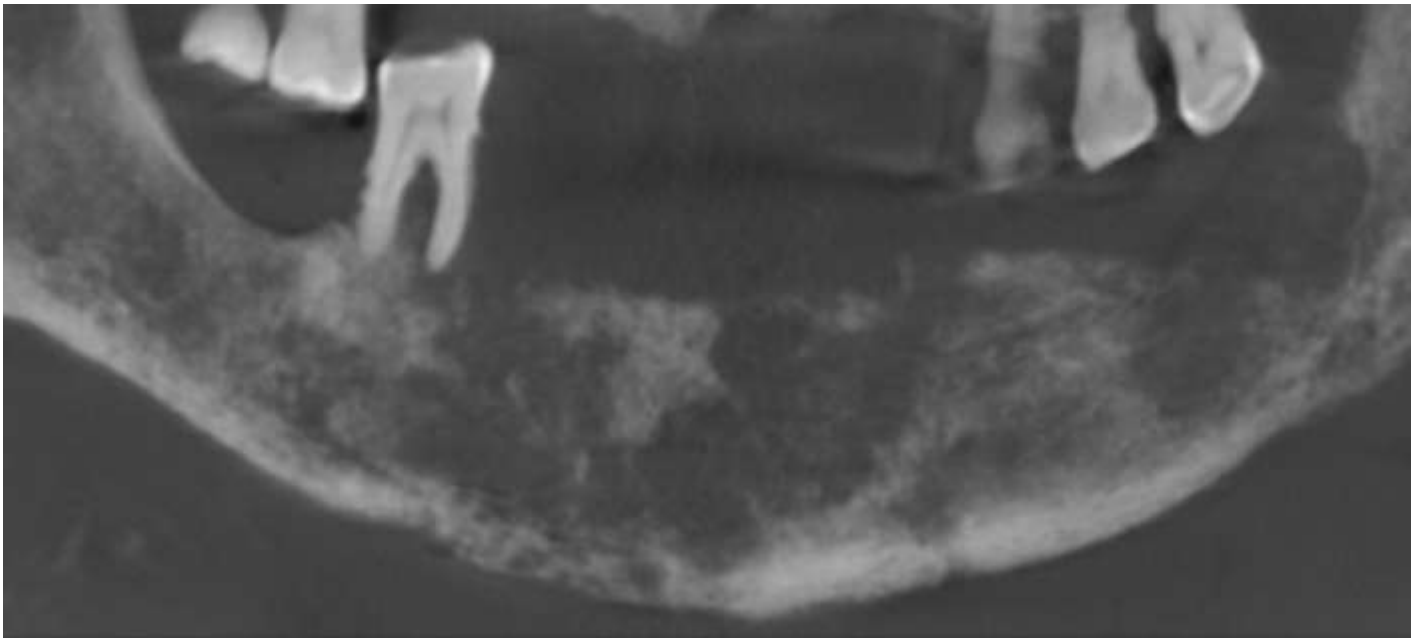


FIGURE 7A EROSIVE INVASION

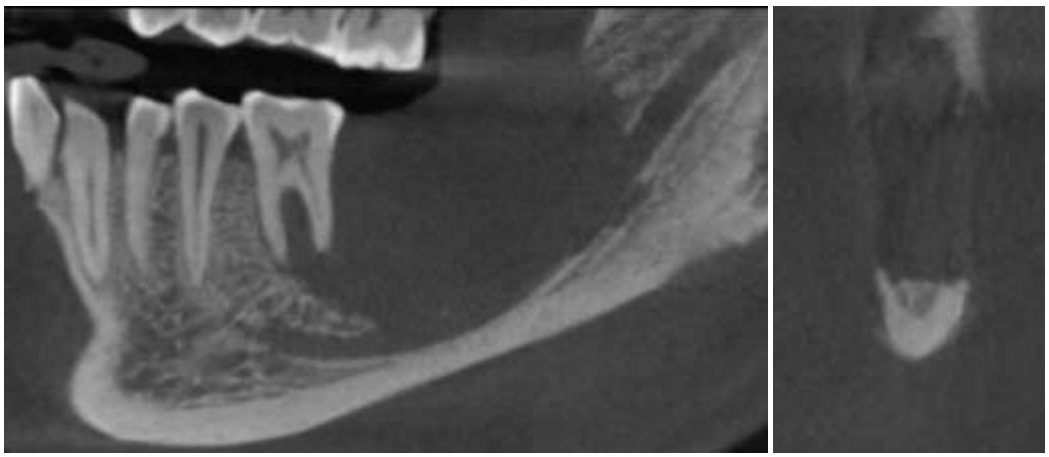


FIGURE 7B INFILTRATIVE INVASION

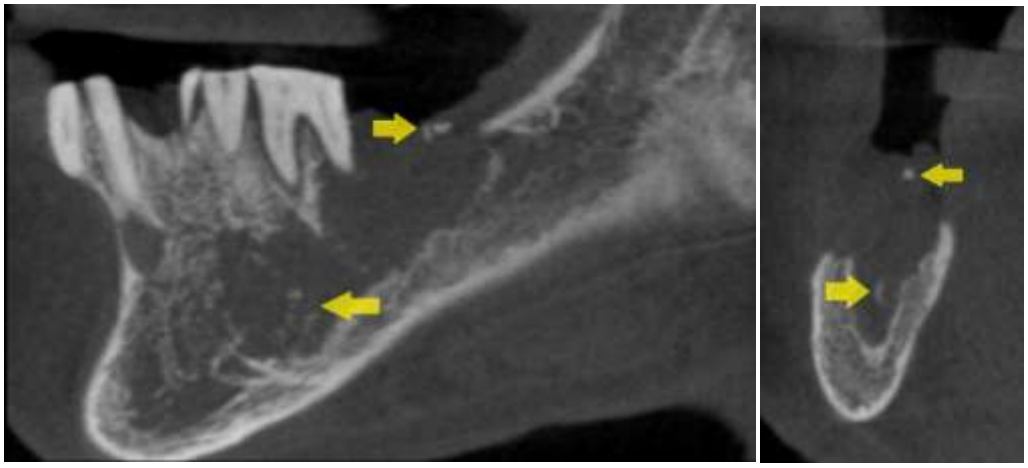


FIGURE 7C MIXED INVASION

FIGURE 8A BUCCAL CORTEX PERFORATION ((Coronal and Axial Section)

FIGURE 8B LINGUAL CORTX PERFORATION (Sagittal and Axial Section)

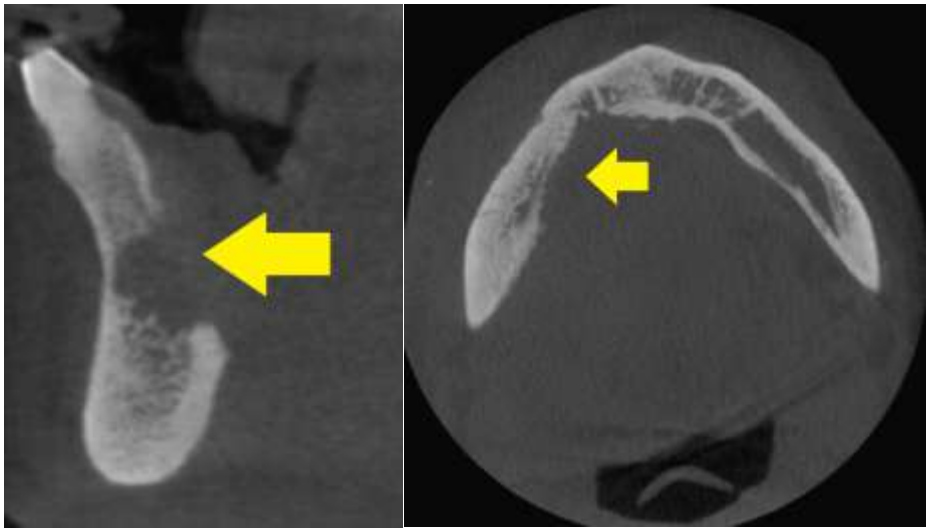


FIGURE 8C BICORTICAL PERIOSTEAL REACTION (Coronal and Axial Section)

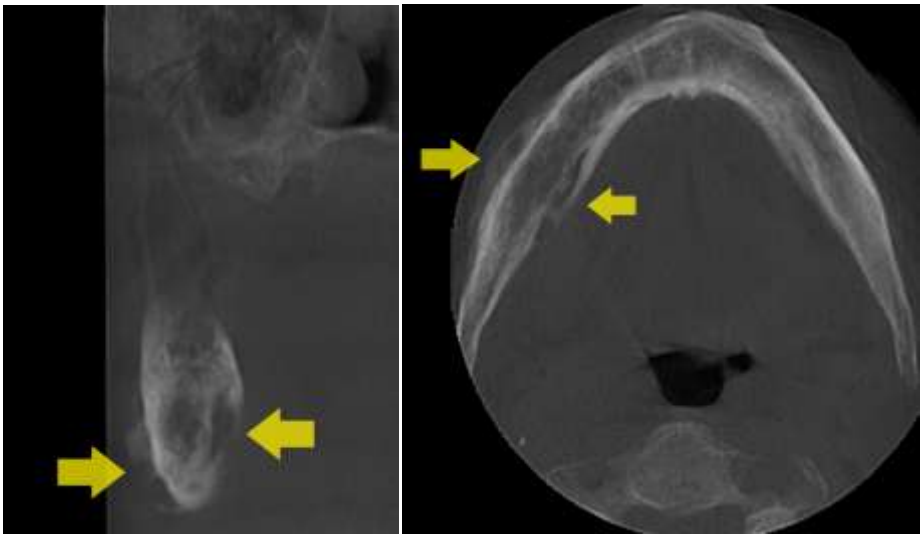
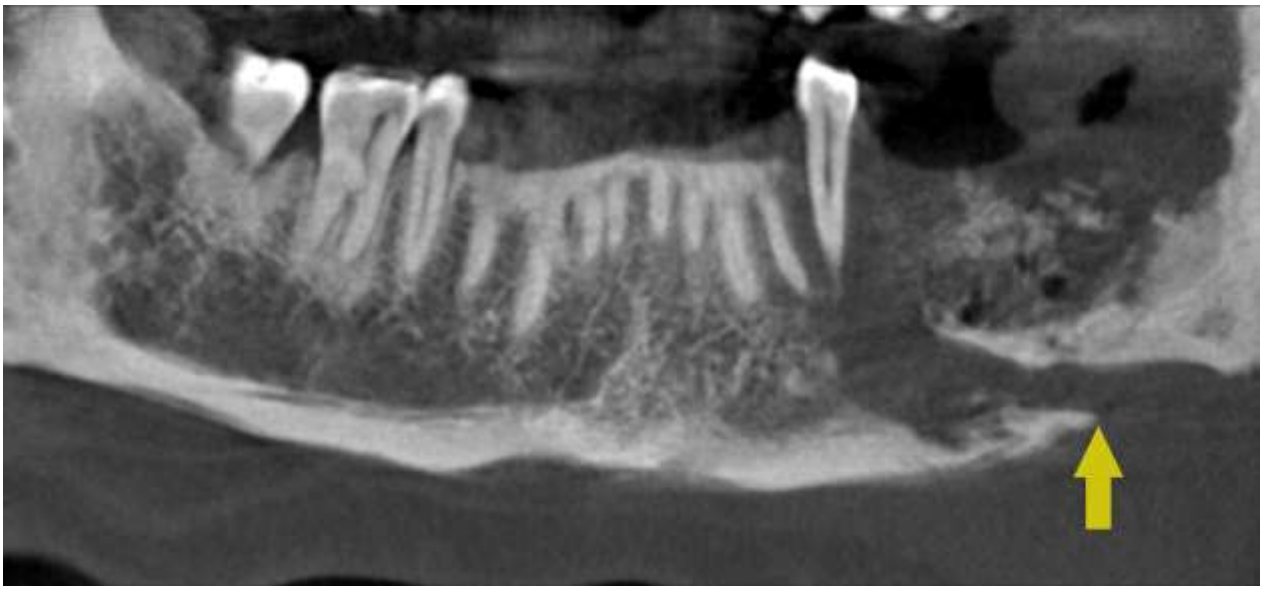


FIGURE 9

PATHOLOGICAL FRACTURE OF LEFT BODY OF MANDIBLE

(Panoramic Reconstruction, Axial section and Coronal Section)



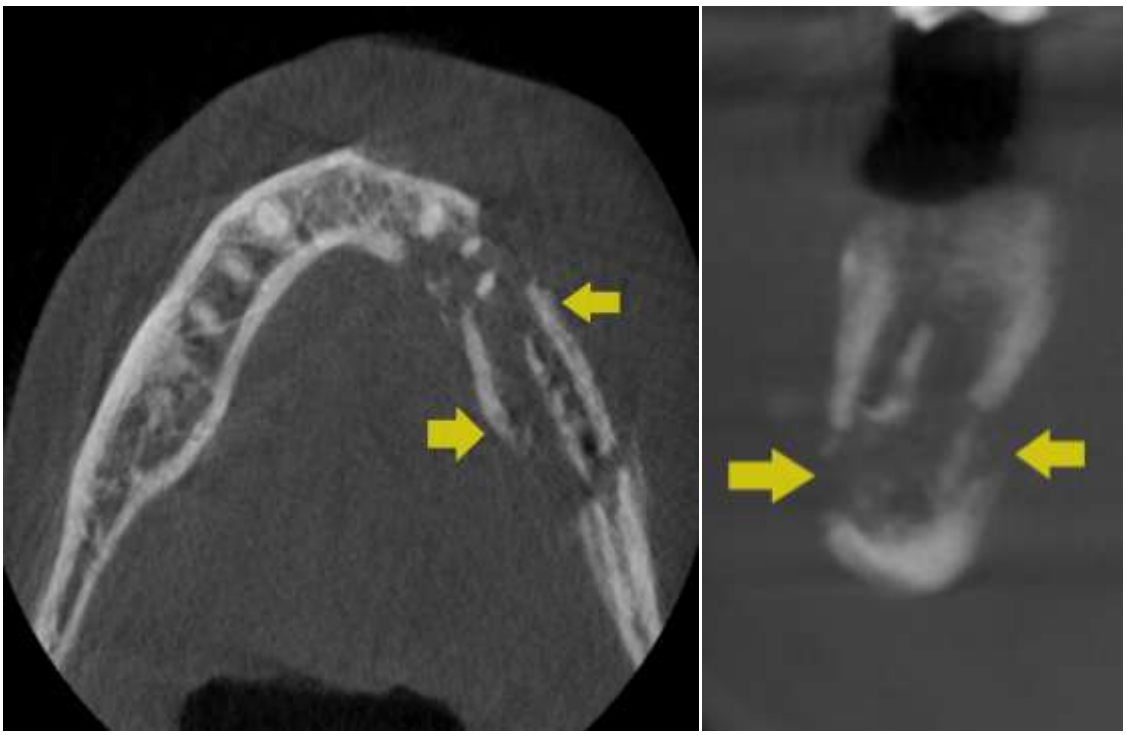


FIGURE 10 A. WIDENED LEFT INFERIOR ALVEOLAR CANAL

(Panoramic Reconstruction)

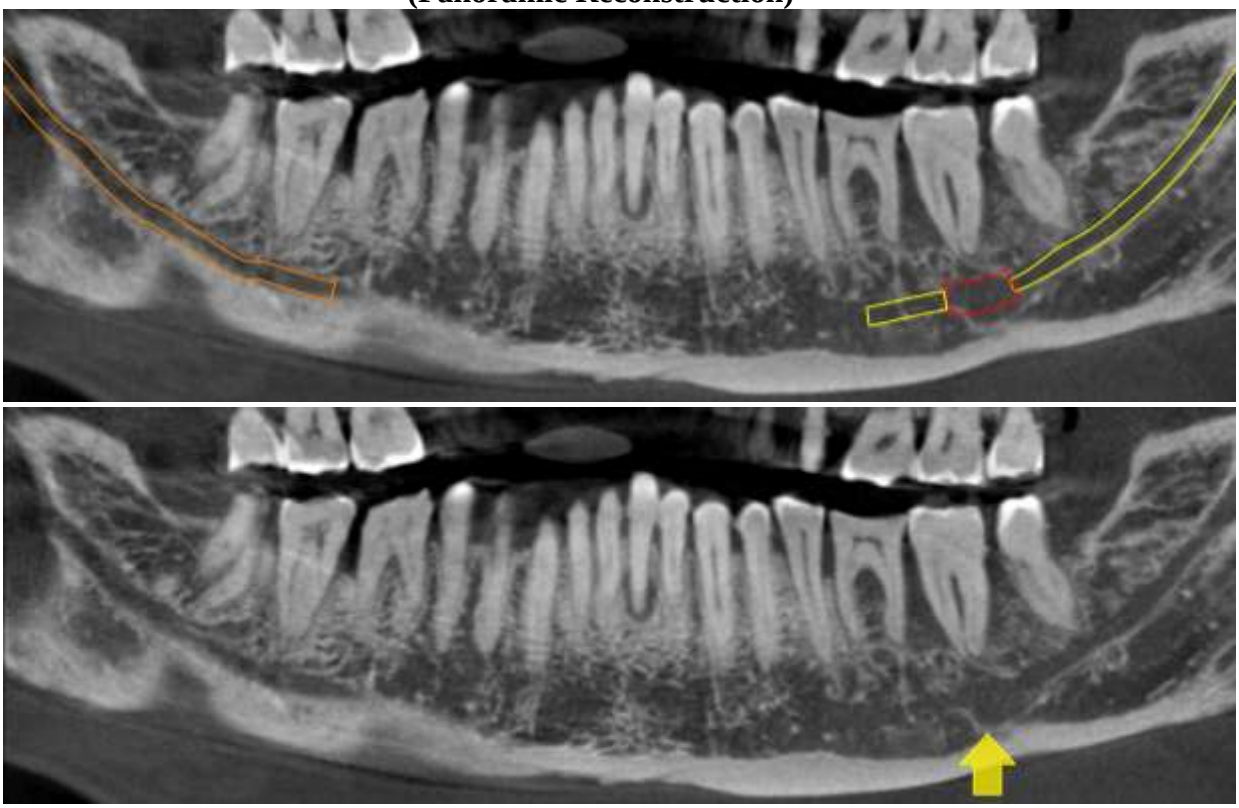


FIGURE 10 B.CORTICAL DESTRUCTION OF LEFT INFERIOR ALVEOLAR CANAL (Panoramic Reconstruction)

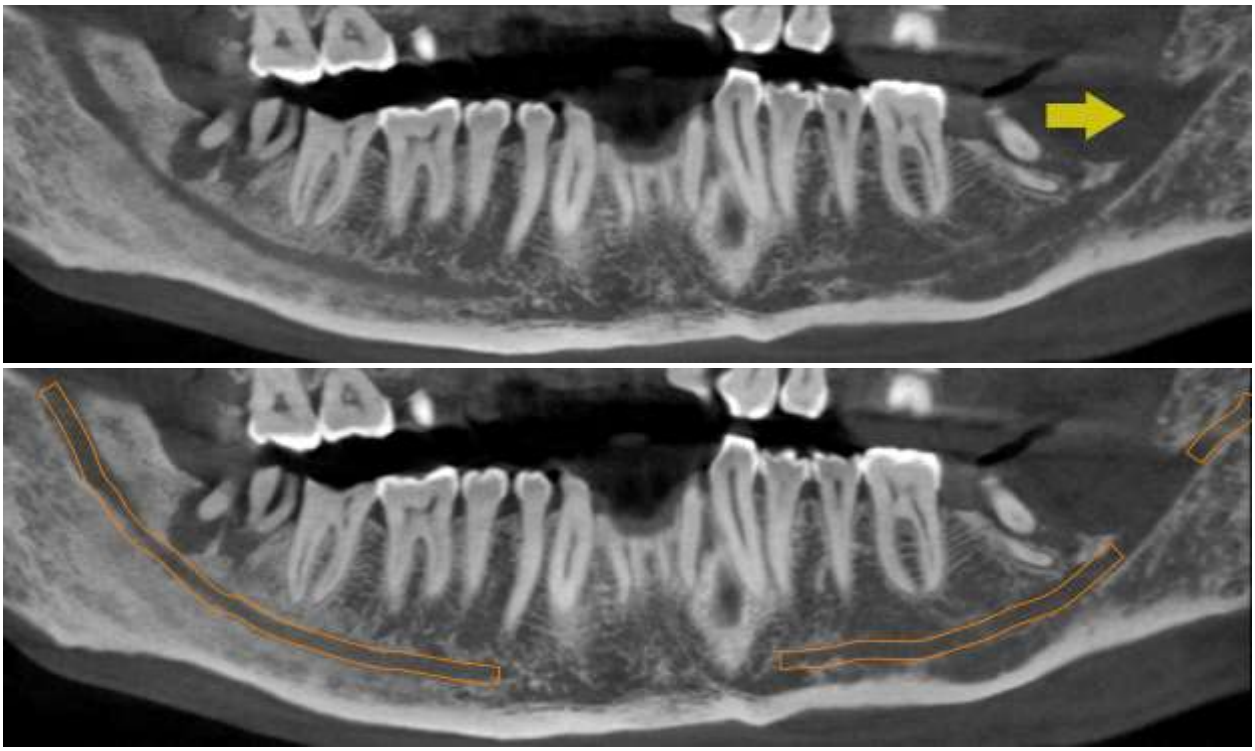


FIGURE 11

CORTICAL DESTRUCTION OF RIGHT MENTAL FORAMEN

(Axial Section and Coronal Section)

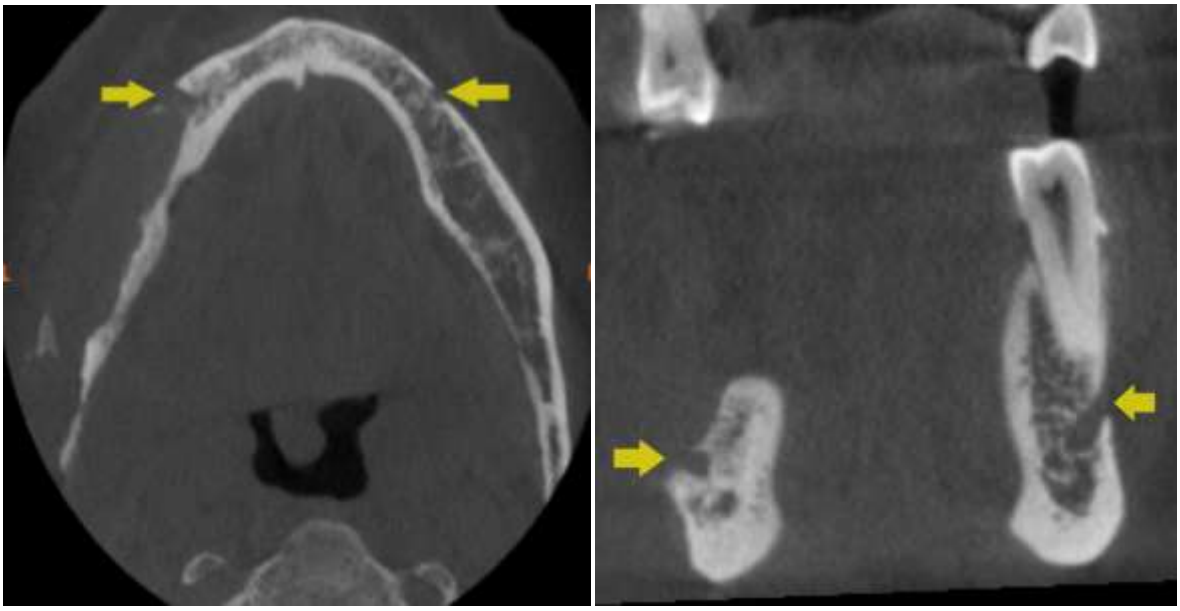


FIGURE 12

SUPERO-LINGUAL DISPLACEMENT OF MANDIBULAR RIGHT 2ND MOLAR

(3D Reconstruction and Coronal Section)

FIGURE 13 A. WIDENING OF PERIODONTAL LIGAMENT SPACE

(Panoramic Reconstruction and Axial Section)

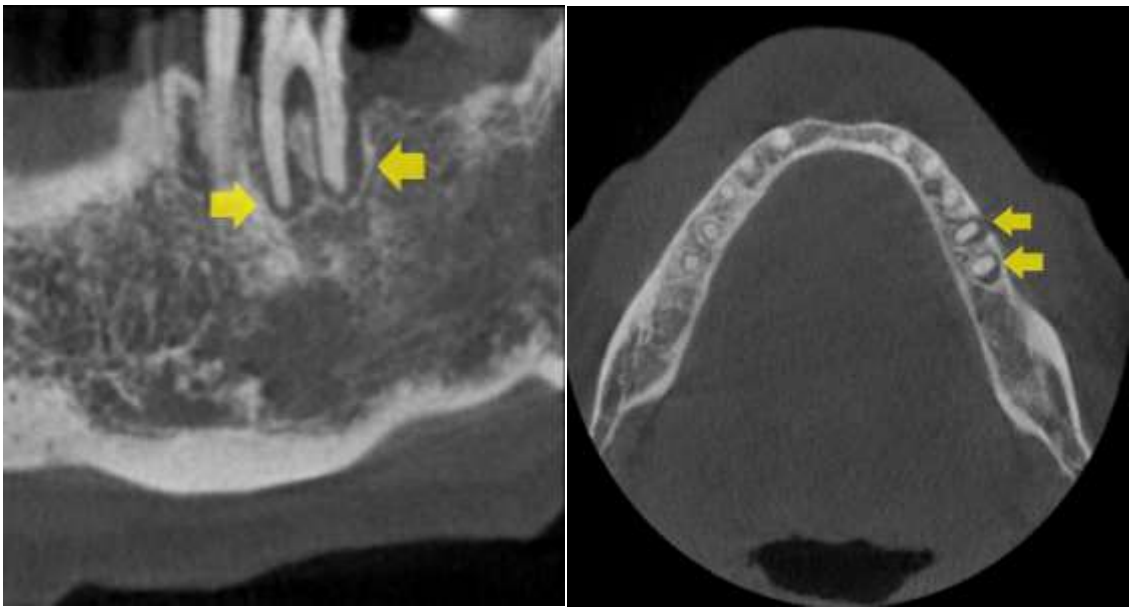
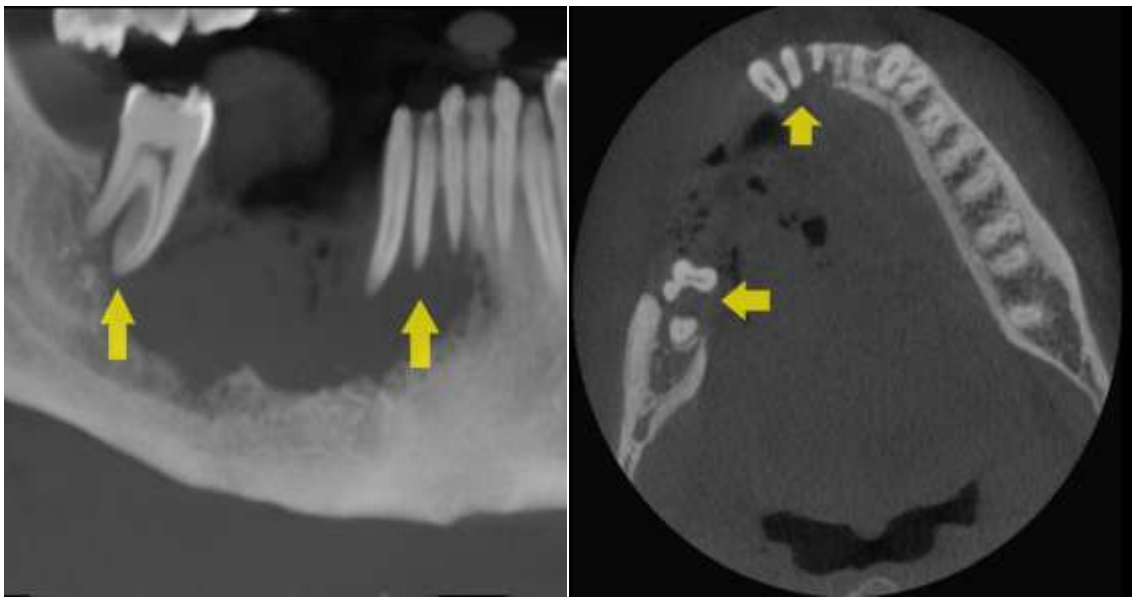


FIGURE 13B. LOSS OF LAMINA DURA AND DESTRUCTION OF PERIODONTAL LIGAMENT SPACE (FLOATING TEETH)

(Panoramic Reconstruction and Axial Section)



STATISTICAL ANALYSIS

Statistical analysis was done with SPSS (Statistical Package for Social Sciences) version 24.

Distribution and frequency were estimated for each variable. Arithmetic Mean and Standard Deviation were estimated for different variables. Comparison of the quantitative and parametric data was done using One Way ANOVA and the comparison of the categorical data was done using CHI square test. P value of < 0.05 was considered as significant in the present study.

The P value or calculated probability was the estimated probability of rejecting the null hypothesis (H0) of a study question when that hypothesis was true. The smaller the p- value, the more significant the result was said to be. All P- values are two tailed, and confidence intervals were calculated at the 95% level. Differences between the two set of data were considered significant when $p \leq 0.05$.

RESULTS AND OBSERVATIONS

This clinical study was conducted among the patients attending the Department of Oral Medicine and Radiology, Tamilnadu Government Dental College and Hospital. Totally 30 cases of Mandibular cancer were included, having complaints of malignant lesion of oral cavity, and were assessed for clinical features such as Presentation, Site, Size, Lymphnode involvement, Association with OSMF, Status of dentition. These patients were then subjected to CBCT of Mandible for radiological assessment. Descriptive analysis of the Clinical Features, Radiological features and Histopathological Features was done and association of Radiological features to Clinical feature and Histopathological was assessed.

Chart 1 shows gender distribution. Out of 30 patients in the study, there were 10 (33%) females and 20 (67 %) males. A male predilection of 2:1 was observed..

Table 1 shows the age of distribution of the cases. Minimum age of the patient in the study was 40 and maximum age was 70 year with mean age of 54.9 years.

Chart 2 shows distribution Clinical presentation. Out of 30 Patients 83% patients presented with Ulceroprolifearative lesion, 10% with ulcerative lesion and 7% with hair-like growth showing verrucous pattern.

Chart 3 represents the Distribution of Clinical Site involvement. Right posterior Alveolus was most commonly involved site in the distribution with 36% cases followed by Left posterior alveolus in 31%. Left Anterior Alveolus and Retromolar areas were least involved in the cases. Amongst these cases, 54% patient had Oral submucous fibrosis (OSMF) and 54% Patients had Parasthesia.

Chart 4 shows distribution of Clinical size of lesion. 74% of cases had size of lesion > 4cm (T_3) whereas only 3% cases presented with Lesion size less than 2 cm (T_1). Out of 30 cases,

40% had no Regional Lymphnode involvement. Amongst the cases having Lymphnode involvement 43% of cases had highest N2b stage of Lymphnode metastasis, and only 3% cases had N1 stage involvement. None of the cases were found to be having distant metastasis. TNM Staging was done based on Clinical findings. In these cases 60% of cases were graded as TNM Stage IV, 23% were Stage III and 17% cases were Stage II. None of cases were graded as Stage I.

Chart 5 shows distribution of effect on Dentition status. On assessment of status of Dentition in 24% of cases Teeth were missing secondary to exfoliation. 63% cases showed Mobility and 13 % cases showed presence of displacement.

All the patients were subjected to CBCT for mandible. Radiological analysis was performed for all cases.

On assessment with CBCT, Maximum cases (35%) with invasion were present in relation to Right Posterior Alveolus. **Chart 6** shows correlation of clinical and CBCT site of involvement. On correlating the Site of involvement it was found that sites of involvement were more in assessment with CBCT than Clinical assessment, showing spread of Bone invasion goes beyond the site of Clinical lesion**..**

Table 2 shows extension of Bone invasion within mandible. Mean value of Extension of Bone invasion in Supero inferior (A) and Antero-posterior (B) direction were 22.7mm and 43.6mm respectively with mean of ratios of A and B being 0.7. This explains patter of bone invasion seen in mandible being faster in antero posterior direction than in supero inferior direction**.** Total 13% of cases were found to be crossing midline and entering in opposite quadrant.

Table 3 shows distribution of pattern of bone invasion in mandible**.** Out of 30 cases 27% cases had Erosive pattern of bone invasion, 30%cases had infiltrative pattern of bone invasion and 43% cases had mixed invasive pattern**.** The pattern of bone of bone invasion was associated with Clinical Presentation. Erosive pattern was found exclusively in lesions presenting as Ulceroprolifearative growth. All cases of verrucous presentation appeared to have mixed pattern of bone invasion. All the lesions presenting as ulcer had infiltrative pattern of invasion. Value of Pearson Chi square test for this association was 10.18 and it was statistically significant (P<0.05). This association is depicted in **Chart 7.**

The Invasion pattern was also associated with Parasthesia.75% of cases with erosive pattern and 89% of cases with infiltrative pattern presented with Parasthesia, whereas 69% cases with mixed invasion pattern had no Parasthesia. Value of Pearson Chi square test for this association was 8.5 and it was statistically significant (P<0.05). This association is depicted in **Chart 8.**

Table 4 depicts the distribution of cortical involvement in mandible**.** On assessment of involvement of cortex, 77% cases had buccal cortical involvement and 80% cases had Lingual cortical involvement. Cortical perforation was most frequently noted, it being 60% of times present on buccal cortex, 50% of times in lingual cortex. 7% of cases of buccal cortex involvement and 3% cases of lingual cortex involvement presented in form of periosteal reaction. While checking association between cortical involvements with Parasthesia, it was found that 78% of cases with Buccal Cortex perforation and 87% of cases with Lingual Cortex Perforation had Parasthesia. 100% of cases with buccal cortical erosion and 75% of cases with lingual cortical erosion did not have Parasthesia. 100% of cases with periosteal reaction were associated with Parasthesia. Values of Pearson Chi square test for this association was for Buccal and lingual Cortex were 11.08 and 10.97. Both of them were statistically significant (P<0.05).

Table 5 shows details of cases with presence of pathological fracture. On assessment of Inferior border of mandible it was found that 27% patients had pathological fracture, amongst these cases out of which 75% were females. The M: F ratio was 1:3. Mean age of these patients was 55.9.This association between Gender and Pathological fracture was statistically significant (P<0.05).

Chart 9 shows association between pathological fractures with midline crossing. 13.3% cases were found to be crossing midline, amongst these, 75% cases were associated with pathological fracture. Value of Pearson Chi square test for this association was 5.51 and it was statistically significant (P<0.05).

Table 6 shows distribution of effects found in Inferior Alveolar Nerve (IAN) canal and mental foramen. On assessment it was found that 67% of cases had IAN Canal involvement. Amongst these 95% presented in form of cortical destruction of canal and 5% had widening of canal present. In 33% of cases observed, mental foramen was involved with 60% of cases appearing as cortical destruction whereas 40% presented in form of cortical erosion.

When association of this IAN involvement with clinical presentation was done, it was noted that all the cases presenting as ulcerative lesion had IAN Canal perforation present. Only case of widening of canal was noted in verrucous lesion. All cases of intact IAN canal were present in association with Ulceroproliferative growth. Value of Pearson Chi square test for this association was 16.8 and it was statistically significant (P<0.05). This association is depicted in **Chart 10.**

IAN involvement was also associated with Invasion pattern. On assessment it was found that 100% of cases with infiltrative invasion had done cortical destruction of IAN Canal and 54% of mixed invasion lesion had IAN Canal intact. Value of Pearson Chi square test for this association was 8.5 and it was statistically significant (P<0.05). This association is depicted in **Chart 11.**

On assessing Correlation of IAN Canal involvement with complaint of Parasthesia, we noted that out of 16 out of 19cases with IAN Canal cortical destruction had Parasthesia. 8 out of 10 cases without complaint of Parasthesia had their IAN intact. Value of Pearson Chi square test for this association was 12.8 and it was statistically significant ($P<0.05$). This association is depicted in **Chart 12.**

Table 7 shows distribution of effects on dental and periodontal structure seen on CBCT assessment. It was found that out of cases with teeth present, 36% had loss of lamina dura present. Most common effect seen on PDL Space was widening with 61% of cases. Tooth displacement was found in 22% of cases.

Following CBCT examination all the cases were graded as Stage IV in TNM staging. All the cases were examined with Incisional Biopsy for histopathological examination. **Table 8** shows distribution of Histopathological diagnosis amongst sample cases.

TABLES

TABLE 1: AGE DISTRIBUTION (n=30)

Parameter	*n*	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Age	30	40.0	70.0	55	9.21

TABLE 2: EXTENSION OF INVASION IN MANDIBLE(n=30)

Extension	*Minimum (mm)*	*Maximum (mm)*	*Mean*	*Std. Deviation*
Supero-Inferior (A)	8.80	62.70	22.7	10.87
Antero-Posterior (B)	3.80	128.80	43.6	22.52
A:B RATIO	0.20	3.37	0.70	0.68

TABLE 3: DISTRIBUTION OF PATTERN OF INVASION IN BONE(n=30)

Invasion Pattern	*Frequency*	*Percent*
Erosive	8	27
Invasive (Infiltrative)	9	30
Mixed	13	43
Total	30	100.0

TABLE 4: DISTRIBUTION OF CORTEX INVOLVEMENT(n=30)

Cortex	*CBCT Feature*			
	Not involved	*Erosion*	*Perforation*	*Periosteal reaction*
Buccal Cortex	23%	10%	60%	7%
Lingual Corex	20%	27%	50%	3%
Bilateral cortex	0.0%	3%	94%	3%

TABLE 5: AGE AND GENDER DISTRIBUTION AMOGST PATIENTS WITH PATHOLOGICAL FRACTURE (n=30)

Serial no.	*Age*	*Gender*
1.	50	F
2.	52	F
3.	60	F
4.	60	F
5.	48	M
6.	50	M
7.	60	F
8.	67	F
	Mean Age: 55.9	*M:F = 1 : 3*

TABLE 6: IAN CANAL AND MENTAL FORAMEN INVOLVEMENT (n=30)

IAN canal	Intact	33%
	Widened	3%
	Cortical Destruction	64%
Mental Foramen	Intact	66%
	Erosion	11%
	Cortical Destruction	20%

TABLE 7: CBCT ASSESSMENT OF EFFECT ON DENTITION (n=30)

Structure	*Effect detected on CBCT*	*Percentage*
Lamina Dura	Intact	4%
	Lost	96%
PDL Space	Intact	4%
	Widening	61%
	Destruction (Floating tooth)	35%
Tooth Displacement	Absent	78%
	Present	22%

TABLE 8: HISTOPATHOLOGICAL DIAGNOSIS (n=30)

Histopathological Diagnosis	*Percent of cases*
Well Differentiated Squamous Cell Carcinoma	43%
Moderately Differentiated Squamous Cell Carcinoma	50%
Verrucous Cacinoma	7%

CHARTS

CHART 1: GENDER DISTRIBUTION

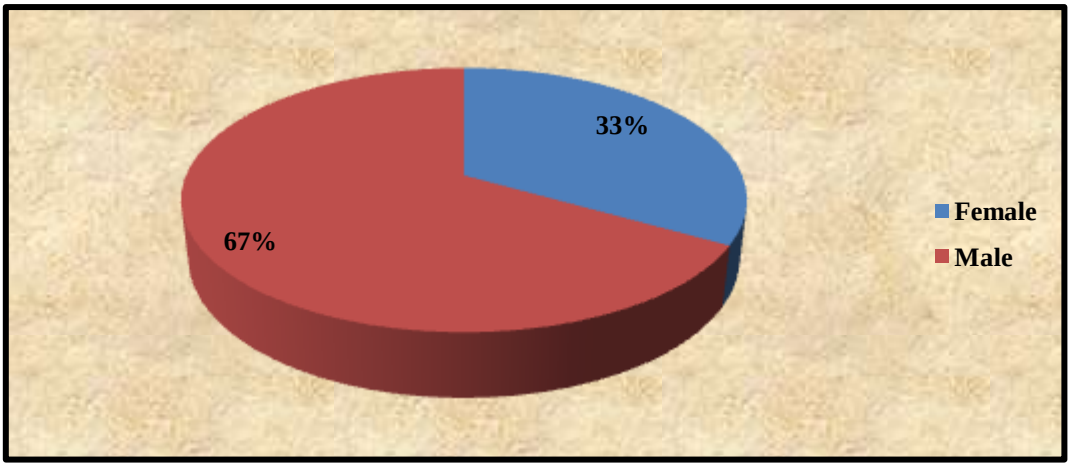


CHART 2: CLINICAL PRESENTATION DISTRIBUTION

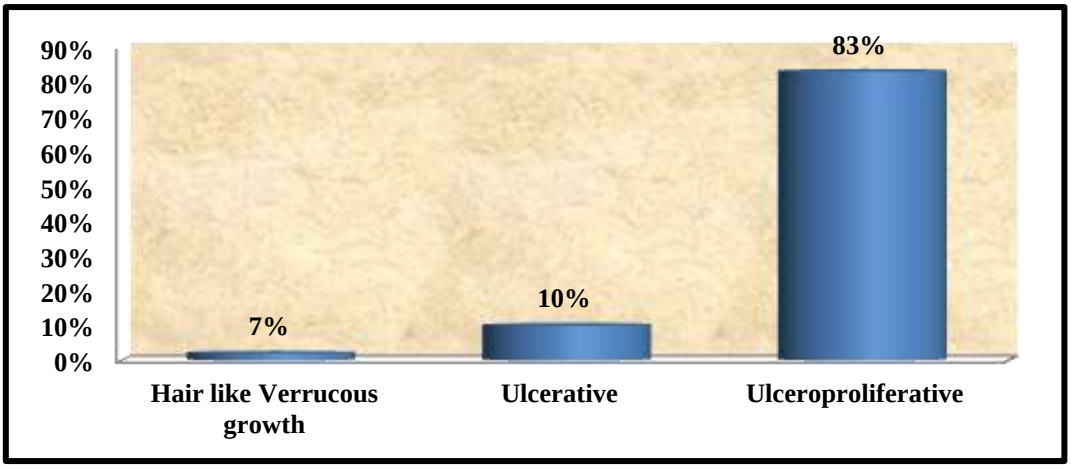


CHART 3: CLINICAL SITE OF LESION DISTRIBUTION

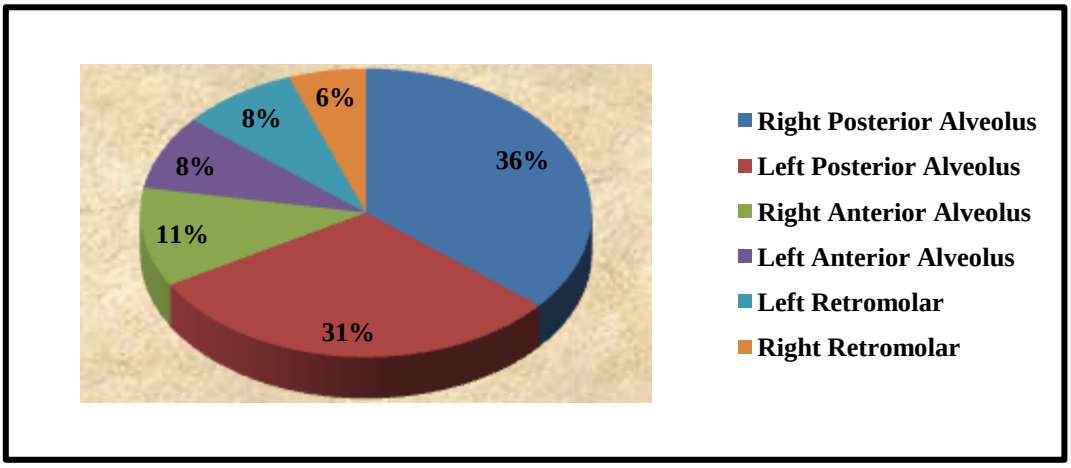


CHART 4: CLINICAL SIZE OF LESION DISTRIBUTION

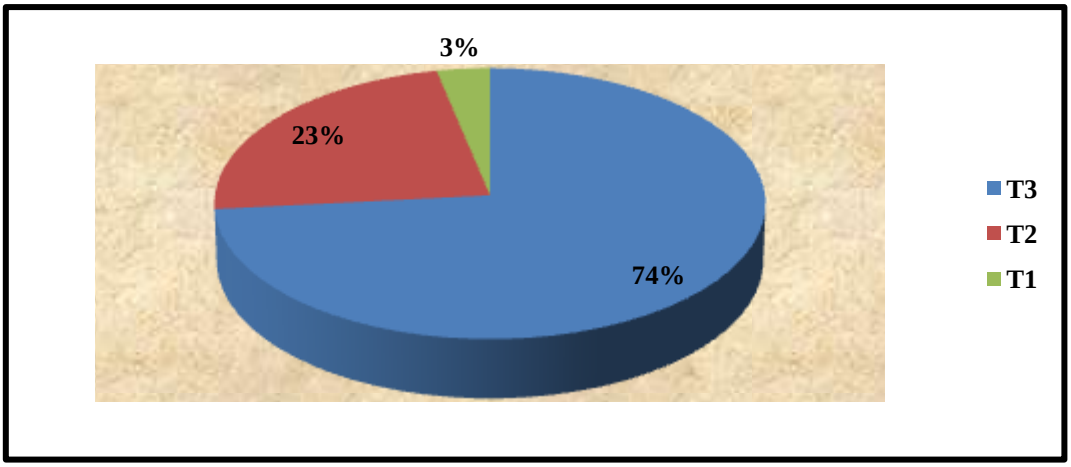


CHART 5: DISTRIBUTION OF EFFECT ON DENTITION

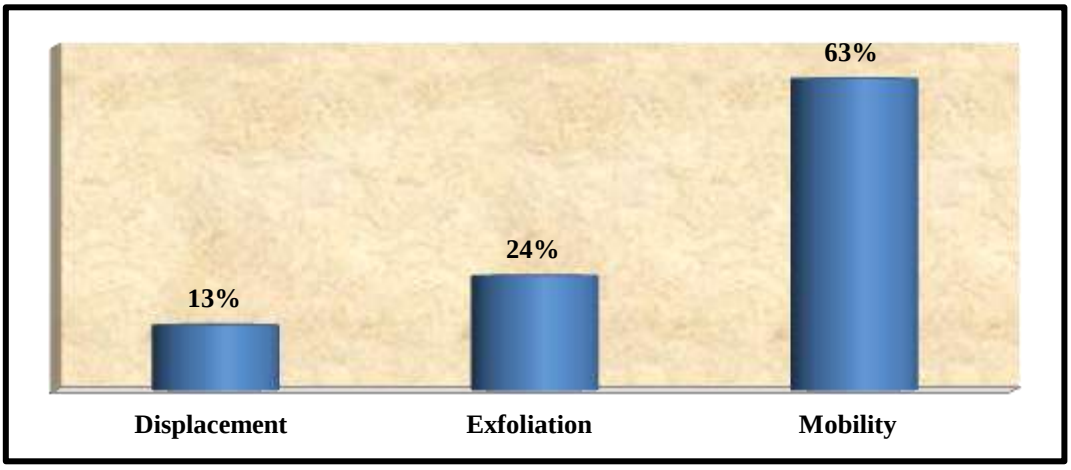


CHART 6: ASSOCIATION BETWEEN CLINICAL AND CBCT SITES OF INVOLVEMENT

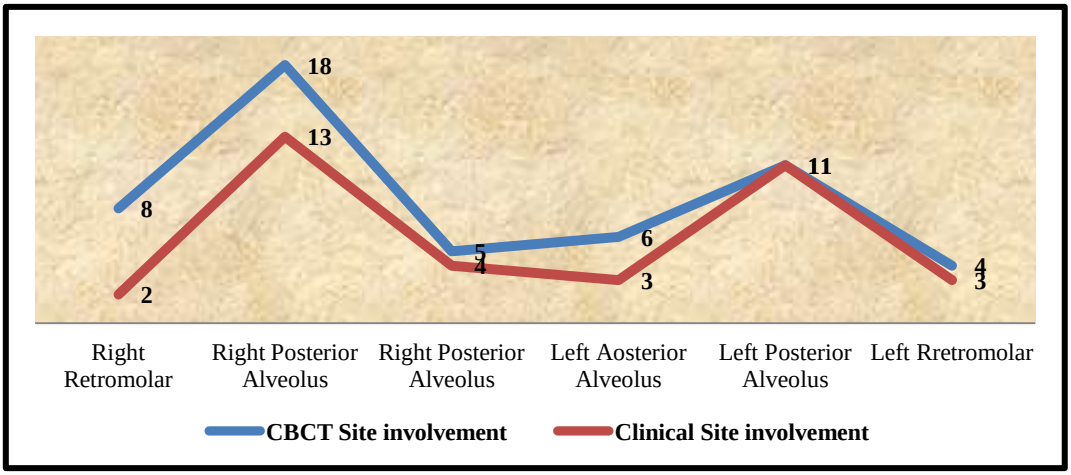


CHART 7: ASSOCIATION BETWEEN CLINICAL PRESENTATION AND CBCT INVASION PATTERN

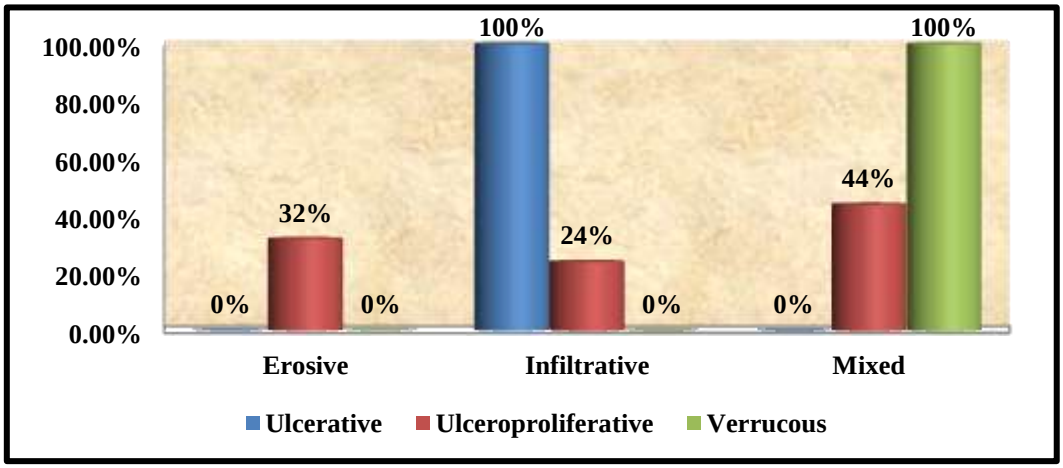


CHART 8: ASSOCIATION OF CBCT INVASION PATTERN WITH PARASTHESIA

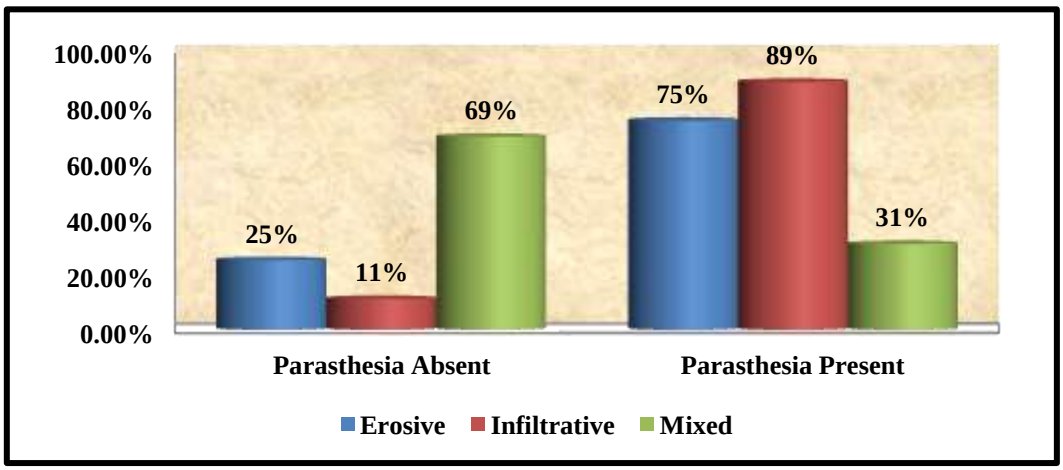


CHART 9: ASSOCIATION OF CROSSING MIDLINE WITH PATHOLOGICAL FRACTURE

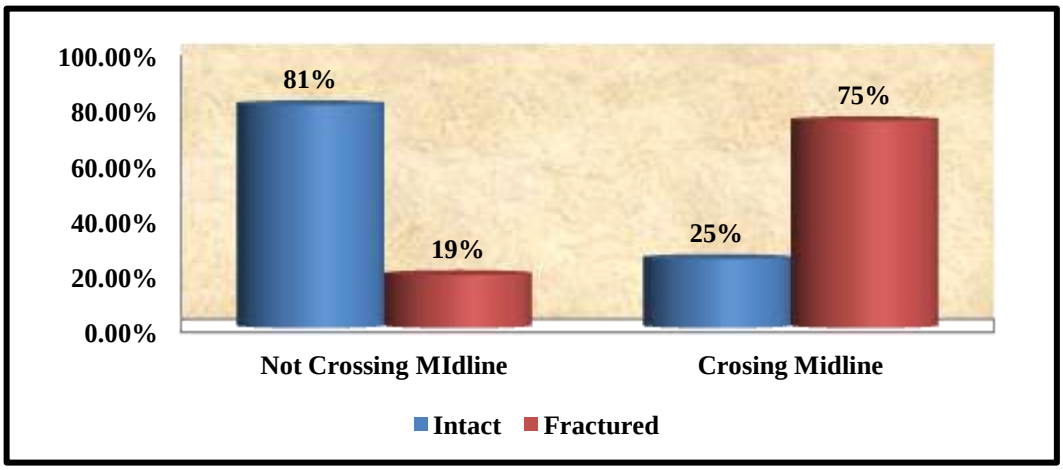


CHART 10: ASSOCIATION OF IAN INVOLVEMENT WITH CLINICAL PRESENTATION

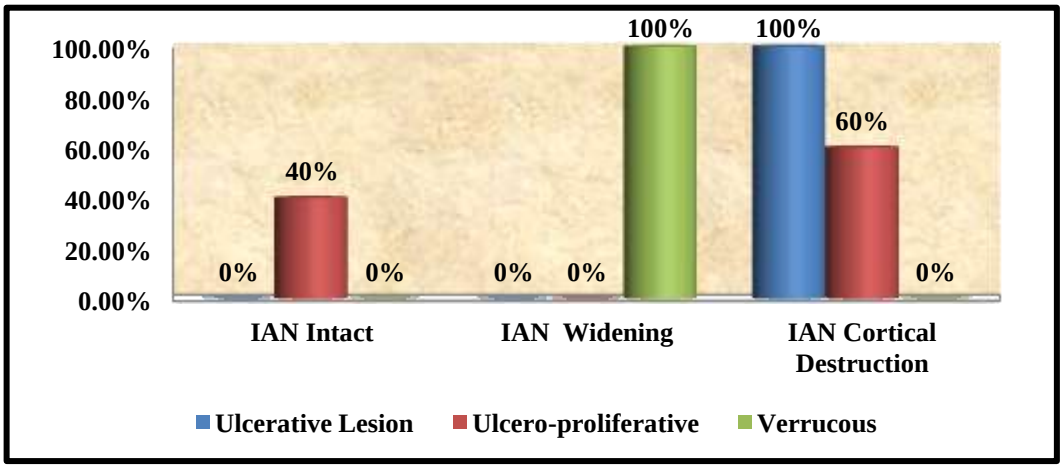


CHART 10: ASSOCIATION OF IAN INVOLVEMENT WITH INVASION PATTERN

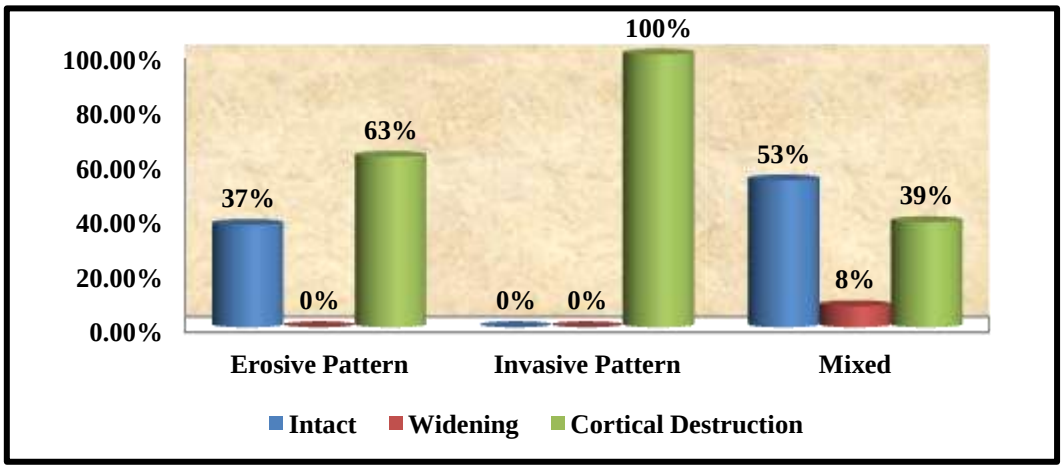
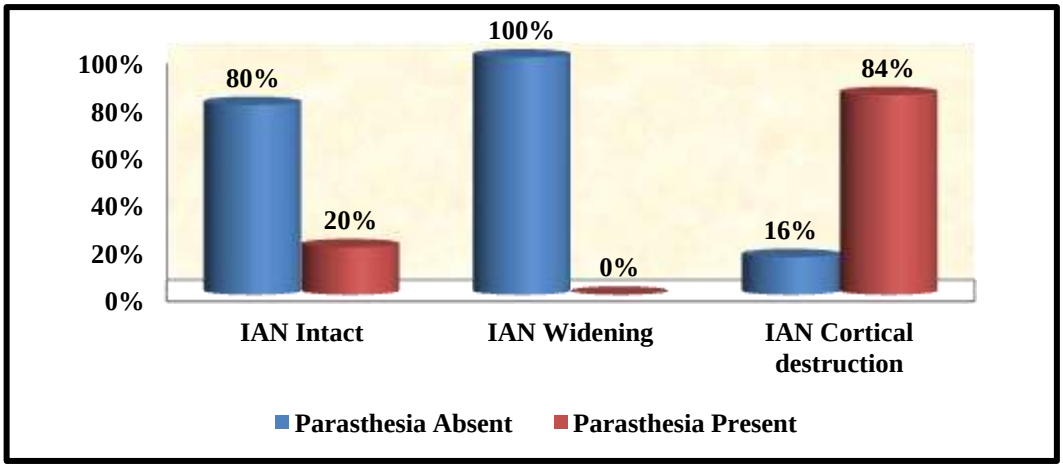


CHART 11: ASSOCIATION OF IAN INVOLVEMENT WITH PARASTHESIA



DISCUSSION

The ingress of CBCT has made a massive impact in the field of Maxillofacial imaging, providing novel method of the three Dimensional evaluation for diagnosis of various pathologies of Maxillofacial region. Even though it is easy to detect oral cancer clinically due to obvious clinical features, signs and symptoms in majority of the cases, the presence, extent and pattern of invasion in Bone and involvement of Intraosseous vital structures are needed to be evaluated for the treatment planing and predict prognosis. MDCT is traditional imaging method of choice to detect intraosseous involvement for treatment planning. Consensus guidelines on Radiation Protection put forward by European Academy of Dental and Maxillofacial Radiology (2011) mentions indication of Limited volume and high resolution CBCT for evaluation of bony invasion of the jaws by oral carcinoma.[88, 89]

Studies done by Czerwonka et al[85] (2017), Hakim et al[86] (2014), Dreiseidler et al[16] (2011), Hendrikx et al[87] (2010) and Momin et al[17] (2009) to compare the ability of CBCT and CT in detecting Bony invasion in Oral cancer have found the Sensitivity of CBCT to be superior than MDCT. Specificity of CBCT in detecting invasion varies in the studies, ranging from 60% to 100%. The reason for this discrepancy is not clear.

No studies have been conducted to describe CBCT features extension and Pattern of Bone Invasion, and its effect on adjacent structures. In this study extension and pattern of Bone invasion and involvement of osseous and intraosseous vital structures were studied. An attempt was made to find association of the Radiological features with Clinical feature and Histopathological features.

In this study, out of total 30 patients, 20 patients (67%) were male and 10 (33%) were female. Gender distribution with male predilection of 2:1 was in with concordance with established male predilection seen in cases of Oral Carcinoma. The increased incidence of Oral cancer in

males has been associated with increased use of different form of tobacco products. This Gender distribution can be seen in **Chart 1**.

As seen in **Table 1**, mean age of study population was found to be 55 Years. This again is in agreement with the fact that Oral cancer is a disease of increasing age, the reason being accumulation of time dependent factors resulting in initiation and progression of genetic events and declining immune surveillance with age that result in malignant change.

As seen in **Chart 2**, Out of 30 Patients 83% patients presented with Ulceroprolifearative lesion, 10% with ulcerative lesion and 7% presented with hair-like growth showing verrucous pattern. The site of lesion is associated with the tobacco use. This study had 67% of cases that involved either right or left posterior alveolus as seen in **Chart 3**. This is in concordance with the fact that in Indian subcontinent the cancers of gingivobuccal sulcus, tongue, and buccal mucosa are common due to placement of tobacco quid under the tongue, under the buccal mucosa and under the lip. Cancer of floor of mouth and tongue are more prevalent in western countries[3, 4]. Although most oral cavity squamous cell carcinomas begin as a red-white patch, this classic presentation is eventually destroyed by a developing exophytic or endophytic mass. Exophytic carcinomas are mass-forming lesions, and may be nodular, fungating, papillary, or verruciform in appearance. endophytic growth pattern is characterized by a depressed, irregularly shaped, ulcerated central area with a surrounding "rolled" border of normal, red or white mucosa. The rolled border results from invasion of the tumor downward and laterally under adjacent epithelium.

About 50% of patients with oral cancer delay their first visit to a healthcare professional for 1-2 months after becoming aware of symptoms. Reason for delayed detection of cancers range from absence of severe symptoms, financial problems, and unawareness of the public to sometimes delay on health professional's part in referral to specialist.[90,91] As seen in **Chart**

4, 74% of cases presented with size of lesion > 4cm (T_3) and 60% had Regional Lymphnode involvement. Amongst the cases having Lymphnode involvement 43% of cases had highest $N2_b$ stage of Lymphnode metastasis. These data is in concordance with fact that first detection of cancer is done at relatively advanced stage.

Amongst all the cases of the study, 60% of patients had Parasthesia of ipsilateral lower lip and gingiva of the mandibular teeth. These findings are suggestive of invasion of tumour into Inferior alveolar canal leading to destruction of the inferior alveolar nerve passing through the canal which provides sensory supply to the areas of lower lip, and gingiva.[46]

Chart 5 shows distribution of effect on Teeth in terms of tooth loss, mobility and displacement. On assessment of status of Dentition it was found that in 24% of cases Teeth were missing secondary to exfoliation. 63% cases showed Mobility and 13 % cases showed presence of displacement.

All the patients were subjected to CBCT for mandible. Radiological analysis was performed for all cases. On assessing the extension of involvement of areas of mandible and then comparing them with Clinical findings showed that the invasion was present in areas beyond the limits of clinical lesion. **Chart 6** depicts the areas involved clinically compared with radiological evidence of presence of bony invasion. On Clinical Examination 60% of cases were graded as TNM Stage IV, 23% were Stage III and 17% cases were Stage II. None of cases were graded as Stage I. CBCT examination all cases were found to be invading the bone and were staged as Stage IV. These findings highlight importance of CBCT investigation in evaluating presence and extension of invasion and in treatment planing of Oral Cancer. Size assessed by clinical examination alone disregards the actual area of involvement and area of the jaw that requires to be excised is more compared to area of clinical involvement of jaw as the bony invasion crosses the boundary of clinical involvement

extension. However it has to be noted that in addition to clinical osseous involvement of mandible by Oral cancer, invasion in to soft tissue and surrounding spaces also requires attention as well does the involvement f regional lymphnode by metastasis. CBCT has poor soft tissue window and is of little or no help in determining presence or extension of involvement of soft tissue invasion.[85, 86] MRI is best modality to evaluate presence of invasion into soft tissue i.e. Muscles, Spaces, Tongue, Floor of mouth, Pharynx and to detect regional lymphnode metastasis.[57, 58] Provided the finding that CBCT being more sensitive than MDCT in detecting bone invasion[16,17,87-89], it is advisable to use CBCT with MRI in treatment planing in cases of Oral cancer.

Presence of Extension and Pattern of bony invasion in mandible were studied in CBCT. On studying pattern of extension it was found that Bone invasion in Supero inferior (A) and Antero-posterior (B) direction were 22.7mm and 43.6mm respectively with mean of ratios of A and B being 0.7 **(Table 2).** The pattern that appears here suggests that invasion by cancer is more in horizontal direction compared with vertical spread. This explains invasion being faster in antero posterior direction than in supero inferior direction**.** This also explains why only 27% of cases had presence of pathological fracture even after 74% of cases being detected in T_3 stage. Total 13% of cases were found to be crossing midline and entering in opposite quadrant.

All the three pattern of invasion described by **Nakamaya**, i.e. Erosive, Infiltrative and Mixed were found in the patients.[46] Out of 30 cases 27% cases had Erosive pattern of bone invasion, 30% cases had infiltrative pattern of bone invasion and 43% cases had mixed invasive pattern**. (Table 3)** The pattern of bone of bone invasion was associated with Clinical Presentation. Erosive pattern was found exclusively in lesions presenting as Ulceroprolifearative growth. All cases of verrucous presentation appeared to have mixed pattern of bone invasion. All the lesions presenting as ulcer (endophytic growth) had

infiltrative pattern of invasion. When the association of pattern of invasion was done with Clinical and other radiological features, the infiltrative/invasive pattern was found to be most aggressive form in terms of destruction of osseous and intraosseous structures. 89% of cases with infiltrative pattern presented with Parasthesia **(Table 8),** 100% of cases with infiltrative invasion had bone cortical destruction **(Chart 11)**, 75% of cases with pathological fractures had invasive pattern of bone invasion. The mixed pattern of invasion was the least aggressive form amongst three patterns. This study proves endophytic growth being more aggressive than Exophytic growth.

In the study, assessment of involvement of cortex revealed 77% cases had buccal cortical involvement and 80% cases had Lingual cortical involvement. 7% of cases of buccal cortex involvement and 3% cases of lingual cortex involvement also presented in form of periosteal reaction **(Table 4).** This shows that Cortex sometimes in addition to destructive response may also appear with periosteal new bone formation.

On assessment of Inferior border of mandible it was found that 27% patients had pathological fracture, amongst these cases 75% were females **(Table 5)**. The M: F ratio was 1:3. Mean age of these patients was 56. Female Gender Predilection and Increased age are in concordance with findings of **C. Jasmin et al**. that the mean age of cancer patients with a pathological fracture is 61 years and the Female: male ratio is 4:1.[92] Female appear to have more frequency of pathological fracture because: (1) women have less bone mass than men to begin with (2) they begin losing it earlier (starting around age 35) (3) they lose it faster than men do (4) after menopause, the ovaries no longer produce estrogen.[92]

As seen in **Table 6,** 67% of cases had Inferior alveolar Canal involvement. Amongst these 95% presented in form of cortical destruction of canal and 5% had widening of canal present. In 33% of cases observed, mental foramen was involved with 60% of cases appearing as

cortical destruction whereas 40% presented in form of cortical erosion. When association of this Inferior alveolar canal involvement with clinical presentation was done, it was noted that all the cases presenting as ulcerative lesion had Inferior alveolar canal perforation present. Only case of widening of canal was noted in verrucous lesion. Possible hypothesis for widening of canal be the growth of tumor along the canal without causing the destruction. All cases of intact Inferior alveolar canal were present in association with Ulceroproliferative growth (**Chart 10).** On assessing Correlation of Inferior alveolar canal involvement with complaint of Parasthesia, we noted that 84% cases with Inferior alveolar canal cortical destruction had Parasthesia. 8 out of 10 cases without complaint of Parasthesia had their IAN intact. These findings show ability of CBCT in detecting involvement of vital structure in the mandible. Involvement of canal in mandible also may allow easy passage of tumor spread in the surrounding organs and use of Soft tissue assessment modality may help in further planing treatment in terms of deciding extent of excision margins. We could note that 16 % of cases with Inferior alveolar canal involvement did not have Parasthesia. The possible cause could be preservation of the inferior alveolar nerve canal fibers or the tumor growing in opposite direction than the canal.

An important assessment is the one of effect on dental and periodontal structures. Many a times in cases of oral cancer it may be decided to treat the case with radiotherapy. In such cases it is required to have prophylactic extraction of compromised teeth before beginning of the radiotherapy so as to prevent post radiotherapy complications such as Osteoradionercrosis.[93] CBCT recorded to evaluate the bony invasion will also help in precisely evaluate the condition and status of Dentition and deciding between extraction and non extraction requirements.

On histopathological examination, 50% cases were moderately differentiated carcinoma, 43% were well differentiated carcinoma and 7% were verrucous carcinoma. In the present study

attempt was made to associate the histopathological features with CBCT features. None of the association was found to be statistically significant.

Although CBCT is helpful and significantly more sensitive in detecting bony invasion by malignant process, its inability to detect soft tissue invasion is a drawback of it being independently used in the treatment planing for oral cancer. Following are some of the Limitations of CBCT

CBCT can only demonstrate limited contrast resolution, main reason being a high scatter radiation during image acquisition as well as inherent artifacts such as flat panel detector related artifacts.

If our objective is to examine hard tissue only, use of CBCT will be undisputed; however, if soft tissue needs to be evaluated, CBCT will not be sufficient for evaluation.

Due to ongoing updates and advances in the technology, the Streaking artifacts and motion artifacts have largely been limited with latest CBCT units; however, they are not completely avoided.

The features descriptive of mandibular invasion by oral cancer process as described in this study can be helpful in detecting extension and pattern bone invasion, effect on adjacent structure, pathological fractures, differentiating the invasion from non malignant process and planing of treatment to decide boundaries of surgical excision of the malignancy and determine the prognosis.

SUMMARY AND CONCLUSION

This Cross-sectional Descriptive study was conducted in Department of Oral Medicine and Radiology to study the Cone Beam Computed tomography features in Patients with Oral cancer with Bony invasion of Mandible. This study included total 30 patients (20 males, 10 females) with primary, untreated, pathologically proven Oral Cancers showing male predominance. The patients in the present study fell into the age group ranging from 40 to 70 years with the mean age of 55 years.

Maximum of Patients (83%) patients presented with Ulceroprolifearative lesion, 10% with ulcerative lesion and 7% had hair-like growth. 74% of cases presented at an advanced stage with tumor size of >4cm (T_3). 60% of cases also had presence of Lymphnode involvement. 60% of patients had complaints of Parasthesia of ipsilateral lower lip and chin region with Parasthesia of gingival tissue of ipsilateral mandibular teeth. Mandibular cancer appeared to be affecting dentition in forms of Mobility, Displacement an Exfoliation , all three present in frequency of 13%, 63% and 24%.

On CBCT examination it was found that areas of invasion appeared to be more than the clinical extension of the lesion. It was also noticeable that the spread of invasion was faster and more in antero-posterior direction than in vertical direction. 13% of cases were found to be crossing midline. On assessment of pattern of invasion the mixed invasion pattern was found to be most common amongst the cases, with infiltrative pattern being most aggressive in terms of destruction of osseous structure and intraosseous structure whereas the erosive pattern was found to be least aggressive amongst the three forms. Prevalence of pathological fractures amongst the study group showed obvious female gender predilection. Involvement of inferior alveolar canal was in form of cortical destruction (95%), with only 5% cases presenting as canal widening. 84% cases with Inferior alveolar Canal cortical destruction had

Parasthesia. None of the association between radiological and histopathological features was found to statistically significant. Limitation of CBCT is the inability to detect soft tissue invasion. The study describes features of CBCT related to Bony invasion in cases of oral cancer. The drawback of use of CBCT in assessment of bony invasion for treatment planing is that it cannot assess the amount of Soft tissue invasion and MRI needs to be recorded to find out soft. However, a study conducted on a larger population will be required to postulate associations between histopathological features and radiological features.

BIBLIOGRAPHY

1. Sadaksharam Jayachandran. Clinical Epidemiological Study of Oral Pre-cancer and Cancer in a Tertiary/Referral Hospital. Ann Natl Acad Med Sci (India), 2016;52(3): 155-165.
2. Johnson NW, Jayasekara P, Amarasinghe AA. Squamous cell carcinoma and precursor lesions of the oral cavity: epidemiology and etiology. Periodontol 2000. 2011;57:19–37.
3. Fan CY. Epigenetic alterations in head and neck cancer: Prevalence, clinical significance, and implications.Curr Oncol Rep. 2004;6:152–61
4. Silverman S., Jr Demographics and occurrence of oral and pharyngeal cancers. The outcomes, the trends, the challenge. J Am Dent Assoc 2001; 132: 7S–11S
5. Hari Ram et al Oral Cancer: Risk Factors and Molecular Pathogenesis j. Maxillofac. Oral Surg.(Apr-June 2011) 10(2):132–137
6. Upile T, Fisher C, Jerjes W, El Maaytah M, Singh S, Sudhoff H, et al. Recent technological developments: in situ histopathological interrogation of surgical tissues and resection margins. Head Face Med 2007; 3: 13
7. Tshering Vogel DW, Zbaeren P, Thoeny HC. Cancer of the oral cavity and oropharynx. Cancer Imaging 2010; 10: 62–72
8. Brockenbrough JM, Petruzzelli GJ, Lomasney L. DentaScan as an accurate method of predicting mandibular invasion in patients with squamous cell carcinoma of the oral cavity. Arch Otolaryngol Head Neck Surg 2003; 129: 113–117
9. Liao CT, Chang JTC, Wang HM, Ng SH, Hsueh C, Lee LY, et al. Surgical outcome of T4a and resected T4b oral cavity cancer. Cancer 2006; 107: 337–40

10. Cohen EE, Baru J, Huo D, Haraf DJ, Crowley M, Witt ME, et al. Efficacy and safety of treating T4 oral cavity tumors with primary chemoradiotherapy. Head Neck 2009; 31: 1013–1021
11. Vidiri A, Guerrisi A, Pellini R, Manciocco V, Covello R, Mattioni O, et al. Multi-detector row computed tomography (MDCT) and magnetic resonance imaging (MRI) in the evaluation of the mandibular invasion by squamous cell carcinomas (SCC) of the oral cavity. Correlation with pathological data. J Exp Clin Cancer Res 2010; 29: 73
12. Nahmias C, Lemmens C, Faul D, Carlson E, Long M, Blodgett T, et al. Does reducing CT artifacts from dental implants influence the PET interpretation in PET/CT studies of oral cancer and head and neck cancer? J Nucl Med 2008; 49: 1047–1052
13. Babin E, Desmonts C, Hamon M, Bénateau H, Hitier M. PET/CT for assessing mandibular invasion by intraoral squamous cell carcinomas. Clin Otolaryngol 2008;33:47–51
14. Goerres GW, Schmid DT, Schuknecht B, Eyrich GK. Bone invasion in patients with oral cavity cancer: comparison of conventional CT with PET/CT and SPECT/CT. Radiology 2005; 237: 281–287
15. Wakasugi-Sato N, Kodama M, Matsuo K, Yamamoto N, Oda M, Ishikawa A, et al. Advanced clinical usefulness of ultrasonography for diseases in oral and maxillofacial regions. Int J Dent. [serial on internet]. 2010
16. Dreiseidler T, Alarabi N, Ritter L, Rothamel D, Scheer M, Zöller JE, et al. A comparison of multislice computerized tomography, cone-beam computerized tomography, and single photon emission computerized tomography for the assessment of bone invasion by oral malignancies. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 112: 367–374

17. Momin MA, Okochi K, Watanabe H, Imaizumi A, Omura K, Amagasa T, et al. Diagnostic accuracy of cone-beam CT in the assessment of mandibular invasion of lower gingival carcinoma: comparison with conventional panoramic radiography. Eur J Radiol 2009; 72: 75–81
18. Angelopoulos C, Scarfe WC, Farman AG. A comparison of maxillofacial CBCT and medical CT. Atlas Oral Maxillofac. Surg. Clin. North Am. 2012;20(1):1-17
19. Petrelli NJ, Winer EP, Brahmer J, et al. Clinical Cancer Advances 2009: major research advances in cancer treatment, prevention, and screening—a report from the American Society of Clinical Oncology. J Clin Oncol. 2009;27(35):6052–69
20. Oral and oropharyngeal carcinoma , Burket's Oral medicine ; Greenburg; Glick; Ship; Twelfth edition
21. R. Sankaranarayanan, E. Masuyer, R. Swaminathan, J. Ferlay, and S. Whelan, "Head and neck cancer: a global perspective on epidemiology and prognosis," Anticancer Research, vol. 18, no. 6 B, pp. 4779–4786, 1998.
22. Ken Russell Coelho, "Challenges of the Oral Cancer Burden in India," Journal of Cancer Epidemiology, vol. 2012, Article ID 701932, 17 pages, 2012.
23. GLOBOCAN 2012: Estimated Cancer Incidence, Mortality and Prevalence Worldwide in 2012 v1.0. by Ferlay J, Soerjomataram I, Ervik M, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin DM, Forman D, Bray
24. Mathur A, Jain, M Shiva M, et al (2007). Tobacco habits and risk of oral cancer: a retrospective study in India. Iranian J Blood and Cancer, 3, 111-6
25. Gabriel HE, Liu Z, Crott JW, et al. (2006). A comparison of carotenoids, retinoids, and tocopherols in the serum and buccal mucosa of chronic cigarette smokers versus nonsmokers. Cancer Epidemiol Biomarkers Prev 15(5):993-999.

26. Chen YK, Huang HC, Lin LM, Lin Cc. Primary oral squamous cell carcinoma: an analysis of 703 cases in southern Taiwan. Oral OncoI1999;3S(2):173-9.
27. Hirata RM, Jaques DA, Chambers RG, Tuttle JR. Mahoney WD. Carcinoma of the oral cavity. An analysis of 478 cases. Ann Sutg 1975;182(2):98-103.
28. Oliver AJ, Helfrick JF, Gard D. Primary oral squamous cell carcinoma: a review of 92 cases. Oral Maxillo/ac Surg 1996;54(8):949-54.
29. Mashberg A, Merletti F, Boffetta P, Gandolfo S, Ozzello F, Fracchia F, et al. Appearance, site of occurrence. and physical and clinical characteristics of oral carcinoma in Torino, Italy. Cancer 1989;63(12):2522-7.
30. Scully C. Bagan J. Oral squamous cell carcinoma: overview of current understanding of aetiopathogenesis and clinical implications. Oral Dis 2009;15(6):388-99.
31. Martinez-conde R. Aguirre JM. Burgos 11. Rivera JM. Clinicopathological factors in early squamous cell carcinoma of the tongue and floor of the mouth. in Biscay (the Basque Country. Spain). Med Oral 2001 ;6(2):87-94.
32. Vallecillo Capilla M. Romero Olid MN. Olmedo Gaya MV. Reyes Botella C. Bustos Ruiz V. Factors related to survival from oral cancer in an Andalusian population sample (Spain). Med Oral Patol Oral Cir BucaI2007;12(7):E518-23.
33. Neville BW. Day TA. Oral cancer and precancerous lesions. CA Cancer J Clin 2002;52:195-215.
34. Ribeiro AC. Silva AR. Simonato LE. Salzedas LM. Sundefeld ML. Soubhia AM. Clinical and histopathological analysis of oral squamous cell carcinoma in young people: a descriptive study in Brazilians. Br J Oral Maxil/oJac Surg 2009;47(2):95-8.
35. Mallet Y. Avalos N. Le Ridant AM. Gangloff P. Moriniere S. Rame JP. et al. Head and neck cancer in young people: a series of 52 sces of the oral tongue in patients aged 35 years or less. Acta OtolaryngoI2009;129(12):1503-8.

36. Jovanovic A, Schulten EA, Kostense PJ, Snow GB, van der Waall. Tobacco and alcohol related to the anatomical site of oral squamous cell carcinoma.] Oral Pathol Med 1993;22(10):459-62.
37. Brandizzi D, Gandolfo M, Velazco Ml, Cabrini Rl, lanfranchi HE. Clinical features and evolution of oral cancer: a study of 274 cases in Buenos Aires, Argentina. Med Oral Patol Oral Cir BucaI2008;13:E544-8.
38. Cuffari L. Tesseroli de Siqueira JT, Nemr K, Rapaport A. Pain complaint as the first symptom of oral cancer: a descriptive study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102(1):56-61.
39. Jainkittivong A. Swasdison S. Thangpisityotin M. Langlais RP. Oral squamous cell carcinoma: a clinicopathological study of 342 Thai cases. J Contemp Dent Pract 2009;10(5):E033-40.
40. Gorsky M. Epstein JB. OakJey C. Le ND. Hay J. Stevenson-Moore P. Carcinoma of the tongue: a case series analysis of clinical presentation. risk factors. staging. and outcome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;98(5): 546-52.
41. J. Bagan, G. Sarrion and Y. Jimenez, “Oral Cancer: Clinical Features,” Oral Oncology, Vol. 46, No. 6, 2010, 414-417
42. Barnes L. Everson JW. Reichart P, Sidransky D. editors. Pathology and genetics of head and neck tumours. Lyon. france: IARC Press; 2005.
43. Byars LT: Surgical management of mandible involved by oral cancer. Suq Gynecol Obstet 98:564-571, 1954. .
44. McGregor AD, MacDonald DG. Routes of entry of squamous cell carcinoma to the mandible. Head Neck Surg. 1988 May-Jun;10(5):294–301try of squamous cell carcinoma to the mandible. Head Neck Surg. 1988 May-Jun;10(5):294–301

45. Byars LT: Extent of mandibular resection required for treatment of oral cancer. MA Arch Surg 70:914-920, 1955.
46. Muller H, Slootweg PJ. Mandibular invasion by oral squamous cell carcinoma clinical aspects. J Cranio-Max-Fac Surg 1990;18: 80-4.
47. Nakayama, Eiji & Radiology, Maxillofacial. (2009). Imaging diagnosis for bone invasion by gingival carcinoma of the mandible: The value and the limitation. Japanese Dental Science Review. 45. 23-30. 10.1016/j.jdsr.2009.03.002.
48. Smoker WRK. Oral cavity. In: Som PM, Curtin HD. Head and neck imaging, 3rd ed. St. Louis: Mosby Year Book, 1995 :488–544
49. American Joint Committee on Cancer, Fleming ID, Cooper JS, Henson DE, et al., eds. AJCC cancer staging manual, 5th ed. Philadelphia: Lippincott Williams & Wilkins
50. Nakayama E, Yoshiura K, Yuasa K, Tabata 0, Araki K, Kanda S, et at. Detection of bone invasion by gingival carcinoma of the mandible: a comparison of intraoral and panoramic radiography and computed tomography. Dentomaxillofac Radiol 1999;28: 351-6.
51. Metz CE. Basic principles of ROC analysis. Semin Nucl Med 1978;8:283-98.
52. Kawano K, Takahashi Y, Takahashi A, Yanagisawa S. Diagnostic accuracy of panoramic radiography for bone invasion by squamous cell carcinoma of the mandibular gingiva. Japanese Journal of Head and Neck Cancer 2007·33:400-5
53. Ohba T, Tokutomi T, Urago A, Funakoshi K. Roentgenological and histological studies on changes of mandible involved by carcinoma of gingiva. Jpn J Rad Med 1974;34:820-34
54. Totsuka Y, Usui Y, Tei K, Fukuda H, Shindo M, lizuka T, et at. Mandibular involvement by squamous cell carcinoma of the lower alveolus: analysis and comparative study of histologic and radiologic features. Head Neck 1991;13:40-50.

55. Imaizumi A, Yoshino N, Yamada I, Nagumo K, Amagasa T, Omura K, et al. A potential pitfall of MR imaging for assessing mandibular invasion of squamous cell carcinoma in the oral cavity. AJNR 2006;27: 114-22.
56. Van Cann EM, Rijpkema M, Heerschap A, Van der Bilt A, Koole R, Stoelinga P JW. Quantitative dynamic contrast-enhanced MRI for the assessment of mandibular invasion by squamous cell carcinoma. Oral Oncol2008;44:1147-54
57. Bolzoni AB, Cappiello J, Piazza C, Peretti G, Maroldi R, Farina 0, et al. Diagnostic accuracy of magnetic resonance imaging in the assessment of mandibular involvement in oral-oropharyngeal squamous cell carcinoma a prospective study. Arch Otolaryngol Head Neck Surg 2004;130:837-43.
58. Van Cann EM, Koole R, Oyen WJG, de Rooy JWJ, de Wilde PC, Slootweg PJ, et al. Assessment of mandibular invasion of squamous cell carcinoma by various modes of imaging: constructing a diagnostic algorithm. Int J Oral Maxillofac Surg 2008;37:535-41.
59. Campbell RS, Baker E, Chippindale AJ, et al. MRI T staging of squamous cell carcinoma of the oral cavity: radiological-pathological correlation. Clin Radiol 1995;50:533–40
60. Chung TS, Yousem DM, Seigerman HM, et al. MR of mandibular invasion in patients with oral and oropharyngeal malignant neoplasms . Am J Neuroradiol 1994;15:1949–55
61. Goerres GW, Schmid DT, Schuknecht B, Eyrich GK. Bone invasion in patients with oral cavity cancer: comparison of conventional CTwith PET/CTand SPECT/CT. Radiology 2005;237:281-7.

62. Babin E, Desmonts C, Hamon M, Beneteau H, Hitier M. PET /CT for assessing mandibular invasion by intraoral squamous cell carcinomas. Clinical Otolaryngology 2008;33:47-51.
63. Uribe S, Rojas L, Rosas C. Accuracy of imaging methods for detection of bone tissue invasion in patients with oral squamous cell carcinoma. Dentomaxillofacial Radiology. 2013;42(6):20120346. doi:10.1259/dmfr.20120346.
64. Linz C, Müller-Richter UD, Buck AK, et al. Performance of cone beam computed tomography in comparison to conventional imaging techniques for the detection of bone invasion in oral cancer. Int J Oral Maxillofac Surg. 2015;44:8–15
65. Mohamed Shweel, Maha IshaK Amer, Ashraf Fathy El-shamanhory, A comparative study of cone-beam CT and multidetector CT in the preoperative assessment of odontogenic cysts and tumors, In The Egyptian Journal of Radiology and Nuclear Medicine, Volume 44, Issue 1, 2013, 23-32.
66. Cevidanes LHS, Styner MA, Proffit WR. Image analysis and superimposition of 3-dimensional cone-beam computed tomography models. Am. J. Orthod. Dentofacial Orthop. 2006;129(5):611-8. doi:10.1016/j.ajodo.2005.12.008.
67. Sukovic P, Brooks S, Perez L, Clinthorne NH. DentoCATTM - a novel design of a cone-beam CT scanner for dentomaxillofacial imaging: introduction and preliminary results. CARS 2001:700-5.
68. Sukovic P. Cone beam computed tomography in craniofacial imaging. Orthod. Craniofac. Res. 2003;6 Suppl 1:31-6; discussion 179-82.
69. Mah JK, Danforth RA, Bumann A, Hatcher D. Radiation absorbed in maxillofacial imaging with a new dental computed tomography device. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 2003;96(4):508-13.

70. Robb RA. The Dynamic Spatial Reconstructor: An X-Ray Video-Fluoroscopic CT Scanner for Dynamic Volume Imaging of Moving Organs. IEEE Trans. Med. Imaging 1982;1(1):22-33.
71. R. Fahrig AJFSLDWH. Use of a C-arm system to generate true threedimensional computed rotational angiograms: preliminary in vitro and in vivo results. Available at: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.111.9465.
72. Saint-Felix D, Trousset Y, Picard C, Ponchut C, Romeas R, Rougee A. In vivo evaluation of a new system for 3D computerized angiography. Phys. Med. Biol. 1994;39(3):583-595.
73. Jaffray D, Siewerdsen J. Cone-beam computed tomography with a flat-panel imager: Initial performance characterization. Med. Phys. 2000;27(6):13111323.
74. Leuzinger M, Dudic A, Giannopoulou C, Kiliaridis S. Root-contact evaluation by panoramic radiography and cone-beam computed tomography of super-high resolution. Am. J. Orthod. Dentofacial Orthop. 2010;137(3):389-92.
75. Ozen T Kamburooğlu K Cebeci ARI Yük el SP Pak oy CS. In e p e a ion of chemically created periapical lesions using 2 different dental cone-beam computerized tomography units, an intraoral digital sensor, and conventional film. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 2009;107(3):42632. doi:10.1016/j.tripleo.2008.08.017.
76. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J. Can. Dent. Assoc. 2006;72(1):7580.
77. Danforth RA: Cone beam volume tomography: A new digital imaging option for dentistry.J Calif Dent Assoc 31:814, 2003

78. Danforth RA, Peck J, Hall P: Cone beam volume tomography: An imaging option for diagnosis of complex mandibular third molar anatomical relationships. J Calif Dent Assoc 31:847,2003
79. Danforth RA, Dus I, Mah J: 3D volume imaging for dentistry: A new dimension.J Calif Dent Assoc 31:817, 2003
80. Brown J, Chatterjee R, Lowe O, et al: A new guide to mandibular resection for oral squamous cell carcinoma based on the Cawood and Howell classification of the mandible. Int J Oral Maxillofac Surg 34:834, 2005
81. Brown J, Griffith JF, Phelps PO, et al: A comparison of different imaging modalities and direct inspection after periosteal stripping in predicting the invasion of the mandible by oral squamous cell carcinoma. Br J Oral Maxillofac Surg 32:347, 1994
82. Arai Y, Tammisalo E, Iwai K, et al: Development of a compact computed tomographic apparatus for dental use. Dentomaxillofac Radiol 28:245, 1999
83. Hashimoto K, Arai Y, Iwai K, et al: A comparison of a new limited cone beam computed tomography machine for dental use with a multidetector row helical CT machine. Oral Surg Oral Med Oral PadlOl Oral Radiol Endod 95:371, 2003
84. James J. Closmann, Brian L. Schmidt, The Use of Cone Beam Computed Tomography as an Aid in Evaluating and Treatment Planning for Mandibular Cancer, Journal of Oral and Maxillofacial Surgery, Volume 65, Issue 4, 2007, Pages 766-771
85. Czerwonka L, Bissada E, Goldstein DP, et al. High-resolution cone-beam computed tomography for assessment of bone invasion in oral cancer: Comparison with conventional computed tomography. Head & Neck. 2017;00:000–000
86. Hakim SG, Wieker H, Trenkle T, et al. Imaging of mandible invasion by oral squamous cell carcinoma using computed tomography, cone-beam computed

tomography and bone scintigraphy with SPECT. Clin Oral Investig. 2014;18(3):961–967

87. Hendrikx AWF, Maal T, Dieleman F, Van Cann EM, Merkx MA. Cone-beam CT in the assessment of mandibular invasion by oral squamous cell carcinoma: results of the preliminary study. Int J Oral Maxillofac Surg. 2010;39(5):436–439
88. Radiation Protection**:** Cone Beam CT for Dental and. Maxillofacial Radiology **(**2011**).** www.sedentexct.com
89. Horner K, Islam M, Flygare L, Tsiklakis K, Whaites E. Basic principles for use of dental cone beam computed tomography: consensus guidelines of the European Academy of Dental and Maxillofacial Radiology. Dentomaxillofac Radiol 2009;38:187–95
90. Kerdpon D, Sriplung H. Factors related to advanced stage oral squamous cell carcinoma in southern Thailand. Oral Oncol. 2001;37:216–221.
91. Allison P, Franco E, Black M, Feine J. The role of professional diagnostic delays in the prognosis of upper aerodigestive tract carcinoma. Oral Oncol. 1998;34:147–153
92. Textbook of Bone metastasis. Edited by C. Jasmin et al. Chichester: Wiley; 2005 p. 163.]
93. Shah JP, Gil Z. Current concepts in management of oral cancer: surgery. Oral Oncol. 2009;45:394–401.

TAMIL NADU GOVERNMENT DENTAL COLLEGE & HOSPITAL, CHENNAI – 3.
TELEPHONE : 044-253403343
FAX: 044- 25300681

Ref No: R. C. NO: 0420/DE/2016 date : 28-07-2016
Sub: IEC review of the research proposals,

Title of the work: Cone Beam Computed Tomography analysis of patients with malignancy involving mandible- A Cross-sectional Descriptive study .

Principal Investigator: Dr. Bhaumik Joshi
II year , MDS

Department : Department of Oral Medicine and Radiology
Tamil Nadu Govt. Dental College & Hospital , Chennai-3

Thank you for submitting your research proposal , which was considered at the Institutional Ethics Committee meeting held on the 1st. July 2016, at TN Govt. Dental College and the documents related to the study referred above were discussed and the modifications done as suggested and reported to us through your letter dated 20-07-2016 have been reviewed.

The decision of the members of the committee , the secretary and the Chairperson IEC of TN Govt. Dental College is here under:

Approved	Approved and advised to proceed with the study
Approved with suggestions	----------
Revision	----------
Rejected	----------

The principal investigators and their team are advised to adhere to the guide lines given below:

1. You should get detailed informed consent from the patients / participants and maintain confidentiality.
2. You should carry out the work without affecting regular work and without extra expenditure to the Institution or the Government.
3. You should inform the IEC, In case of any change of study procedure, site, and investigating guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s) .
6. You should complete the work within specific period and if any extension of time is required, you should apply for permission again to do the work.
7. You should submit the summary of the work to the ethical committee every 3 months and on completion of the work.
8. You should not claim any kind of funds from the institution for doing the work or on completion/ or for any kind of compensations.
9. The members of the IEC have the right to monitor the work without prior intimation.
10. Your work should be carried out under the direct supervision of the guide/ Professor.

MEMBER SECRETARY,
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

CHAIRPERSON
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

PATIENT INFORMATION SHEET

Title of the study: "CBCT Analysis of patients with malignancy involving mandible-A Cross-sectional Descriptive Study.".

Name of research institution - Tamilnadu Government Dental College & Hospital, Chennai-03

Purpose of the study:
The Aim of this study is to evaluate Cone Beam Computed Tomography in analysis of Patients of Malignancy involving mandible

Procedures:
Patient selection followed by obtaining thorough history and informed consent. Complete Clinical Examination (intra and extra oral examination) by using diagnostic instrument set. Provisional Diagnosis as Malignant lesion followed by Cone Beam CT Scan examination and Confirmation through Biopsy

Risk of participation and protection:
Risk of Radiation exposure
Protection: Standard guidelines for radiation protection will be followed.

Benefits:
Patient will be benefited by more accurate evaluation of osseous invasion followed by appropriate treatment for malignancies of mandible. Benefits of the study: description of CBCT features of malignancy involving mandible.

Confidentiality
The identity of the patients participating in the research will be kept confidential throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Participant's rights
Taking part in the study is voluntary. You are free to decide whether to participate in the study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled. The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Compensation: Nil

Contact For queries related to the study: Dr.Bhaumik Joshi
Department of Oral Medicine and Radiology
Tamilnadu Govt. Dental College and Hospital
Chennai – 600003
Phone Number: 9566093099

(For queries related to the rights as a study participant, please write to: The Chairman, The Ethical Committee, Tamilnadu Government Dental College & Hospital, Chennai – 600003)

ஆராய்ச்சி பற்றிய தகவல் படிவம்

கீழ்தாடையின் வாய் புற்றுநோய்க்கான சி.பி.சி.டி. ஆய்வு

இந்த ஆராய்ச்சி செய்யும்பொருட்டு தமிழ்நாடு அரசு பல் மருத்துவமனை மற்றும் மருத்துவக் கல்லூரிக்கு வரும் நோயாளிகள் தேர்வு செய்யப்படுகிறார்கள்.

கீழ்தாடையின் வாய் புற்றுநோய்க்கான சி.பி.சி.டி. கலந்தாய்வு

நோயாளி பற்றிய குறிப்புகள் பிறர் அறியா வண்ணம் ஆராய்ச்சி முடியும்வரை இரகசியமாக பாதுகாக்கப்படும். அதை வெளியிடும் நேரத்தில் எந்த நோயாளியின் தனி அடையாளங்களும் வெளியிட வாய்ப்பு கிடையாது.

இந்த ஆராய்ச்சியில் பங்குபெறுவது நோயாளியின் தனிப்பட்ட முடிவு மற்றும் நோயாளிகள் இந்த ஆராய்ச்சியில் இருந்து எப்பொழுது வேண்டுமானாலும் விலகிக்கொள்ளலாம். நோயாளியின் இந்த முடிவு அவருக்கோ அல்லது ஆராய்ச்சியாளருக்கோ எந்தவித பாதிப்பும் ஏற்படாது என்பதை தெரியப்படுத்துகிறோம்.

இந்த ஆராய்ச்சியில் முடிவுகள் நோயாளிகளுக்கு ஆராய்ச்சி முடியும் தருவாயிலோ அல்லது இடையிலோ தெரிவிக்கப்படும். ஆராய்ச்சியின்பொழுது ஏதும் பின்விளைவுகள் ஏற்பட்டால் அதை சரிசெய்ய தகுந்த உதவிகள் அல்லது தேவையான சிகிச்சைகள் உடனடியாக மேற்கொள்ளப்படும்.

நோயாளியின் பெயர் கையொப்பம்/ கைரேகை

முதன்மை ஆய்வாளர்
தமிழ்நாடு அரசு பல் மருத்துவக் கல்லூரி,
சென்னை-600 003.

Informed Consent Form

Study title **:**

"**CBCT Analysis of patients with malignancy involving mandible-A Cross-sectional Descriptive Study"**

Participant ID No:

"I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this study and understand that I have the right to withdraw from the study at any time without in any way it affecting my further medical care."

Date	Name of the participant	Signature/thumb impression of the participant

[The literate witness selected by the participant must sign the informed consent form. The witness should not have any relationship with the research team; If the participant doesn't want to disclose his / her participation details to others, in view of respecting the wishes of the participant, he / she can be allowed to waive from the witness procedure (This is applicable to literate participant ONLY). This should be documented by the study staff by getting signature from the prospective participant]

_____

_____

"I have witnessed the accurate reading of the consent form to the potential participant and the individual has had opportunity to ask questions. I confirm that the individual has given consent freely"

Date	Name of the witness	Signature of the witness

Date	Name of the interviewer	Signature of the interviewer

ஆராய்ச்சி ஒப்புதல் படிவம்

கீழ்தாடையின் வாய் புற்றுநோய்க்கான சி.பி.சி.டி. ஆய்வு

பெயர் : வயது/பால்:

ஆராய்ச்சி சேர்க்கை எண்: புறநோயாளியின் எண்:

நான் என் சுய நினைவுடன் மற்றும் முழு சுதந்திரத்துடனும் இந்த மருத்துவ ஆராய்ச்சியில் சேர்ந்துகொள்ள ஒப்புதல் அளிக்கிறேன். கீழ் காணப்படும் நிபந்தனைகளுக்கு ஒப்புதல் அளிக்கிறேன். இந்த ஆராய்ச்சியின் நோக்கமும் அதன் சிகிச்சை முறைகளும் எனக்கு திருப்தி அளிக்கும் வகையில் அறிவுறுத்தப்பட்டது.

நான் மருத்துவ சிகிச்சை முரைக்கு முழுமையாக ஒத்துழைத்து ஏதேனும் அசாதாரண நோய் அறிகுறிகள் ஏற்பட்டால் உடனடியாக என் மருத்துவருக்கு தெரிவிக்க ஒப்புக்கொள்கிறேன்.

என் மருத்துவ குறிப்பேடுகளை மருத்துவ ஆராய்ச்சியில் பயன்படுத்தசம்மதிக்கிறேன். இந்த ஆராய்ச்சி மையமும், ஆராய்ச்சியாளரும் என் அடையாளத்தை ரகசியமாக வைத்திருப்பதாக அறிகிறேன்.

நோயாளியின் பெயர் கையொப்பம் தேதி

ஆராய்ச்சியாளர் பெயர் கையொப்பம் தேதி

CASE PROFORMA

"CBCT ANALYSIS OF PATIENTS WITH MALIGNANCY INVOLVING MANDIBLEA CROSS-SECTIONAL DESCRIPTIVE STUDY"

Date: Serial no:

Name: O.P No:

Age/Sex:

Address:

Phone no:

Occupation: Income:

Religion:

Centre: Department of Oral Medicine And Radiology,

Tamil Nadu Govt Dental College & Hospital, Chennai -3

Presenting complaint with duration:

Past medical and surgical history:

Past dental history:

Personal history:

A) Diet:

B) Teeth cleansing habits:

- Cleaning aids used:
- Frequency :

C) Smoking habit:

Material used:

Frequency :

Duration of the habit:

D) Chewing habit:

Material used:

Frequency :

Duration of the habit:

E) Other habits (alcohol, snuff):

Marital status: Menstrual History:

Family history:

CLINICAL EXAMINATION

GENERAL EXAMINATION

Extraoral Examination:

Facial Symmetry

Swelling

Lymph node examination

TMJ Examination

Intraoral examination:

Teeth**:**

Decayed

Mobility

Missing

Filled teeth

Gingiva

Labial and buccal mucosa:

Hard palate:

Soft Palate:

Pillar of fauces and Tonsils:

Tongue:

Floor of the mouth:

Retromolar trigone:

Investigations:

1. Biochemical / Haematological Investigation :
2. Others :

CONE BEAM CT Evaluation

- Coraonal section
- Sagital section
- Axial section
- Nerve tracing
    a) Cortex of canal
    b) Width of canal
- Site of lesion
- Size of lesion(mm)
- Periphery of the lesion
- Internal structure of the lesion
- Effect on Teeth and Periodontal Structures
- Effect on periosteal cortex of mandible
    a) Buccal Cortex
    b) Lingual cortex
    c) Inferior border of mandible

Provisional Diagnosis

Histopathology report

NAME OF THE INVESTIGATOR:

SIGNATURE OF THE INVESTIGATOR:

TRIPARTITE AGREEMENT

This agreement herein after the "Agreement" is entered into on this day ……. between the Tamil Nadu Government Dental College and Hospital represented by its Principal having address at Tamil Nadu Government Dental College and Hospital, Chennai- 600 003 , (hereinafter referred to as, 'the college')

And

Dr. S. JAYACHANDRAN, M.D.S., PhD., aged 54 years working as Professor in Department of Oral medicine and Radiology at the college, having residence address at A.M -16, TNHB quarters, Tod Hunter Nagar, Saidapet, Chennai – 15. (herein after referred to as the 'Principal Investigator')

And

Dr. BHAUMIK JOSHI, aged 26 years currently studying as final year Post graduate student in the Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai -3 (hereafter referred to as the 'PG and co- investigator') residing at Umang stores, At & Po Delol Ta-Kalol, Dist PMS, 389310.

Whereas the 'PG student' as part of his curriculum undertakes to research on "**CBCT analysis of patients with malignancy involving mandible- A cross-sectional descriptive study**" for which purpose the Principal investigator shall act as Principal investigator and the College shall provide the requisite infrastructure based on availability and also provide facility to the PG student as to the extent possible as a Co-investigator

Whereas the parties, by this agreement have mutually agreed to the various issues including in particular the copyright and confidentiality issues that arise in this regard

Now this agreement witnessed as follows:

1. The parties agree that all the Research material and ownership therein shall become the vested right of the college, including in particular all the copyright in the literature including the study, research and all other related papers.
2. To the extent that the college has legal right to do go, shall grant to license or assign the copyright so vested with it for medical and/or commercial usage of interested persons/entities subject to a reasonable terms/conditions including royalty as deemed by the college.
3. The Royalty so received by the college shall be shared equally by all the three parties.
4. The PG/Research student and PG/Principal Investigator shall under no circumstances deal with the copyright, Confidential information and know how-generated during the course of research/study in any manner whatsoever, while shall sole west with the college.
5. The PG student and Principal Investigator undertake not to divulge (or) cause to be divulged any of the confidential information or, know-how to anyone in any manner whatsoever and for any purpose without the express written consent of the college.
6. All expenses pertaining to the research shall be decided upon by the principal investigator/Co-investigator or borne sole by the PG student.(co-investigator)

7. The college shall provide all infrastructure and access facilities within and in other institutes to the extent possible. This includes patient interactions, introductory letters, recommendation letters and such other acts required in this regard.

8. The Principal Investigator shall suitably guide the Student Research right from selection of the Research Topic and Area till its completion. However the selection and conduct of research, topic and area research by the Student Researcher under guidance from the Principal Investigator shall be subject to the prior approval, recommendations and comments of the Ethical Committee of the College constituted for this purpose.

9. It is agreed that as regards other aspects not covered under this agreement, but which pertain to the research undertaken by the PG student, under guidance from the Principal Investigator, the decision of the College shall be binding and final.

10. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act, 1996.

In witness where of the parties herein above mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its Principal PG Student

Witnesses Student Guide

1.

2.

MASTER CHART

Serial no.	Clinical Features												CBCT Findings																H/P
	Age	Gender	Clinical Feature	Site	OSMF	Parasthesia	LN Involvement	T(Clinical)	N	M	TNM (Clinical)	Dentition status	Site	A	B	A:B	Midline	Invasive Pattern	Buccal Cortex	Lingual Cortex	Inferior Border	IAN Canal	Mental Foramen	Tooth displacement	Lamina Dura	PDL Space	TNM Staging	H/P Diagnosis
1	46	M	2	B	1	1	1	3	2a	0	IV	2	B	22	42.2	0.52	0	3	2	0	0	2	0	1	1	1	IV	1
2	70	M	2	A	1	1	1	2	1	0	III	2	A	25.5	44.6	0.57	0	1	0	1	0	0	0	1	1	1	IV	2
3	40	M	2	B	1	1	1	3	2a	0	IV	1	B	24.1	43.2	0.69	0	2	2	2	0	2	1	0	1	2	IV	2
4	51	M	2	B,C	1	1	1	3	2b	0	IV	1	B,C, D	17	58.4	0.29	1	1	2	2	0	2	2	0	1	2	IV	1
5	63	M	2	E	1	0	0	2	0	0	II	1	E	14.1	39.6	0.36	0	1	2	0	0	0	0	0	1	1	IV	2
6	60	F	2	B	0	1	1	1	2a	0	IV	3	B	19	42.8	0.44	0	3	**3**	3	0	2	1	X	X	X	IV	2
7	50	F	1	B	0	1	1	3	2a	0	IV	3	B	16.8	58.6	0.29	0	2	2	2	1	2	1	X	X	X	IV	2
8	44	F	2	B,C	0	1	1	3	2b	0	IV	3	A,B, C,D	31.8	53.2	0.59	0	2	2	2	1	2	2	X	X	X	IV	1
9	45	M	3	B	0	0	0	3	0	0	IV	3	B	10.7	53.1	0.20	0	3	1	0	0	1	0	X	X	X	IV	4

10	51	M	3	B	0	0	0	3	0	0	IV	1	A,B	24.3	50.7	0.48	0	3	1	1	0	2	0	0	1	2	IV	4
11	65	M	2	D,E	1	1	1	3	2b	0	IV	1	D,E	17.2	43.4	0.40	0	3	**3**	0	0	2	0	0	1	1	IV	1
12	60	F	2	E	0	1	1	3	2a	0	IV	3	E,F	22.7	37.3	0.61	0	1	2	2	1	2	0	X	X	X	IV	2
13	65	F	1	E	1	0	0	2	0	0	II	1	E	29.2	19.9	1.47	0	2	2	2	0	2	0	0	1	1	IV	2
14	60	F	2	B	1	1	1	3	2a	0	IV	1	B,C, D	29	91.8	0.32	1	2	2	2	1	2	2	0	1	2	IV	1
15	45	F	2	F	0	0	1	2	0	0	II	1	A,B	13.4	27.2	0.49	0	3	2	0	0	2	0	0	1	1	IV	1
16	60	F	2	E	1	0	1	3	0	0	III	1	A,B	8.8	3.8	2.31	0	3	0	1	0	0	0	0	0	0	IV	1
17	36	M	2	E	0	1	1	3	2a	0	IV	1	E	34.2	52.2	0.66	0	2	2	2	1	2	2	0	1	2	IV	1
18	62	M	2	E	1	0	0	2	0	0	II	1	E	10	35.9	0.28	0	3	1	0	0	0	0	0	1	1	IV	2
19	68	M	2	F	1	0	0	3	0	0	III	1	E,F	30.1	39.6	0.76	0	3	0	1	0	0	0	1	1	1	IV	1
20	50	M	2	B	1	1	0	3	2a	0	IV	1	B	12	28	0.43	0	3	0	1	0	0	0	0	1	1	IV	2
21	50	F	2	C	0	1	0	3	2a	0	IV	3	C,D	22.8	36.1	0.63	1	2	2	2	1	2	2	X	X	X	IV	1
22	47	M	2	B	1	1	1	3	2a	0	IV	3	B	30.2	48.2	0.63	0	1	2	2	0	2	0	X	X	X	IV	1
23	60	M	1	C,D	1	1	1	3	2b	0	IV	1	A,B, C,D, E,F	28.1	128.8	0.22	1	2	2	2	1	2	1	0	1	2	IV	2

24	60	M	2	A	1	1	1	3	2a	0	IV	2	A,B	35.2	20.8	1.70	0	1	2	2	0	2	0	1	1	2	IV	2
25	40	M	2	E	0	0	0	3	0	0	III	1	E	30.8	32	0.96	0	3	0	1	0	0	0	0	1	1	IV	2
26	47	M	2	E	0	0	0	3	0	0	III	1	E	10.8	30.8	0.35	0	3	0	1	0	0	0	0	1	1	IV	1
27	41	M	2	D,E, F	0	0	1	3	0	0	III	1	E,F	14.9	37.2	0.40	0	3	0	1	0	0	0	0	1	1	IV	1
28	67	M	2	E	1	1	1	2	2a	0	IV	1	B	62.7	18.6	3.37	0	2	2	2	0	2	0	0	1	1	IV	2
29	60	M	2	B	1	0	0	2	0	0	II	1	B	14.6	43.1	0.39	0	1	2	2	0	0	0	0	1	1	IV	2
30	67	F	2	B	1	1	1	3	2a	0	III	2	A,B	20.2	48.9	0.41	0	1	2	2	1	2	2	1	1	2	IV	2

A-Maximum Supero-Inferior Extension (mm)

B-Maximum Antero-posterior Extension (mm)

A:B-Ratio of Maximum dimension in Supero-Inferior Extension to Antero-posterior Extension

CBCT-Cone Beam Computed Tomography

H/P-Histopathological Diagnosis

IAN-Inferior Alveolar Nerve

LN-Lymphnode

M-Distant Metastasis

N-Regional Lymphnode involvement status

OSMF- Oral Submucous fibrosis

PDL-Periodontal Ligament space

T-Size of lesion in centimeters